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1913-20

GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF THE INTERIOR
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1913

ISSUED BY THE DIVISION OF MINES
BUREAU OF SCIENCE

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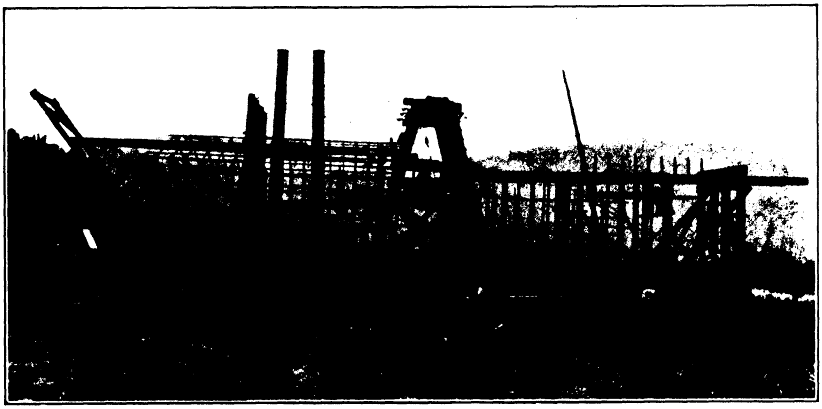

Fig. 1. Machinery and framing in place on pontoon.

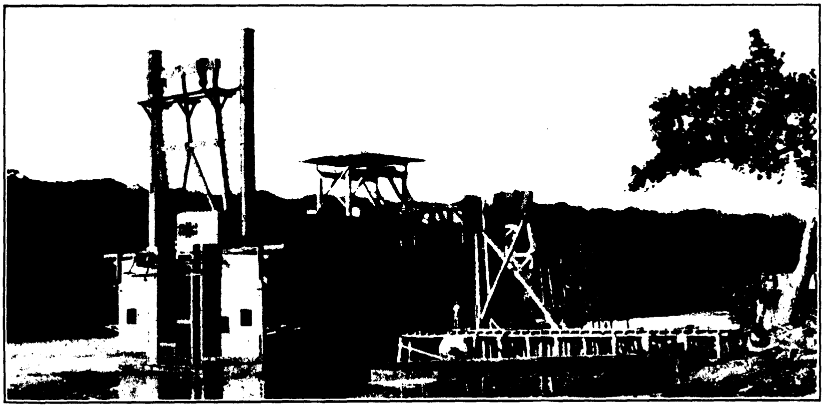

Fig. 2. The completed dredge.

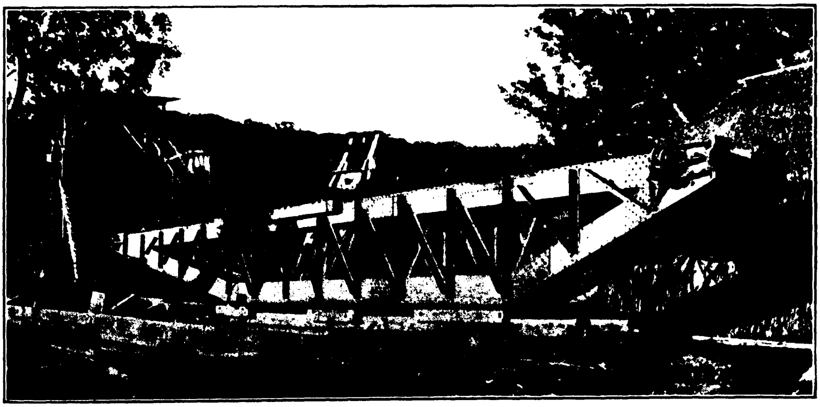

Fig. 3. The digging ladder ready to be put into place.

VIEWS OF THE NEW MALAGUIT DREDGE.

Government of the Philippine Islands
Department of the Interior
Bureau of Science

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1913

ISSUED BY THE DIVISION OF MINES
BUREAU OF SCIENCE

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* Resigned effective at the expiration of leave of absence.

† Appointment as chief of the division of mines of the Bureau of Science effective June 16, 1914.

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MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1913

REVIEW OF THE YEAR

By Warren D. Smith

There was greater activity in mining at the beginning of 1913 than there was at the beginning of the preceding year.

In the iron industry, a new company, the Angat Iron and Smelting Company, has been organized which plans to undertake operations on a scale hitherto unknown in this industry in the Philippines; and one or two additional native smelters have been started. Due largely to the advice given by the Bureau of Science, those interested in iron mining are beginning to change their methods with a view to eliminating waste.

In coal mining there has been no production during the past year, but under the direction of a geologist of the Bureau of Science exploration in the vicinity of Mount Uling, Cebu, has been very successful, and a resumption of production in that island is anticipated. Samples recently secured from a coal seam in Cebu produced a fair coke, which confirms earlier reports of the same thing.

As heretofore, there is the greatest activity in gold mining. The Keystone Mining Company of Masbate has completed the installation of a mill, and has sent the product of its first clean-up to the Bureau of Science for remelting. The Syndicate Mining Company has almost completed the erection of a new mill. The Colorado mill and mine, according to all reports, continues in successful operation. When these three mills are running at their full capacity, this district should lead in production. Renewed interest has been shown in the Benguet district, and new machinery has been ordered for the Benguet Consolidated property. One or two new promising Benguet prospects have been receiving considerable attention, and work has been resumed on the Tumbaga property in Paracale.

In placer fields there is considerable activity. The Cansuran property machinery has been received and is in the course of erection. This will be the first hydraulic plant to operate in the Philippines. The dredge for the property on Umerai River is being set up. In the Paracale district, besides the dredges being installed for the Paracale Bucket Dredging Proprietary, Limited, a new dredge is being erected on Malaguit River. On Gumaus River, some difficulty has been experienced owing to the depth of the ground, but the lengthening of the ladder will probably overcome this. Prospecting continues on Hibong River, Mindanao. This is a new field concerning which the promoters are very sanguine.

The city stone quarry on Talim Island has ceased operation, and the contract for all the stone required for surfacing the streets of Manila has been let to the Rizal Quarry Company. The stone now used is better than the former product.

The final report on the Tayabas oil field has been published by the Bureau of Science, and we must now wait for private or Government capital to solve the question of the quantity of oil to be found there.

Oversized Foldout

STATISTICS OF PRODUCTION

TABLE I.—*Mineral production of the Philippine Islands.*[a]

Product.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Metallic:		*Pesos.*[f]		*Pesos.*[f]
Iron[b] ... metric tons..	141	49,272	227	64,471
Silver[c] ... fine ounces..	7,121	8,664	(c)	(c)
Gold[d] ... do....	27,582	1,140,424	42,011	1,736,724
Nonmetallic:				
Coal ... metric tons..	2,720	20,200	(e)	(e)
Clay products ...	...	453,000	...	460,000
Lime ... metric tons..	...	92,026	11,050	102,700
Sand and gravel ... cubic meters..	...	468,750	689,011	595,645
Stone ... do....	...	651,049	197,039	350,041
Salt ... metric tons..	19,147	574,511	19,500	575,000
Mineral water ... liters..	264,871	55,849	270,000	60,000
Total ...	...	3,513,745	...	3,944,581

[a] Mineral products mined or manufactured, but not sold, at the end of each year are not included.
[b] The statistics for iron represent the quantity and value of iron castings, mostly plowshares.
[c] No silver is mined separately, but a small amount is alloyed with the gold.
[d] The figures for gold include about 200,000 pesos' estimated production by natives.
[e] No economic production. Several hundred tons were mined in the exploration of the Cebu coal fields.
[f] One peso Philippine currency equals 100 centavos equals 50 cents United States currency.

TABLE II.—*Production of gold by districts for 1913.*

	Pesos.
Mancayan Suyoc, estimated native production ...	50,000
Benguet ...	83,281
Ambos Camarines ...	643,443
Masbate, estimated ...	840,000
Mindanao, estimated native production ...	60,000
Nueva Ecija, estimated native production ...	30,000
Pangasinan and lower Benguet, estimated native production ...	30,000
Total ...	1,736,724

THE PARACALE DISTRICT

By F. T. Eddingfield

The production of gold in the Paracale district shows again a large increase over the preceding year. The production for the last seven years is as follows:

Table I.—*Gold production in the Paracale district.*

Year.	Amount dredged.	Increase (+) or decrease (—).
	Pesos. [a]	*Pesos.*
1907	4,000	
1908	152,270	+148,270
1909	216,701	+ 64,431
1910	128,505	— 88,196
1911	198,000	+ 69,495
1912	399,375	+201,375
1913	643,776	+244,401
Total	1,742,627	

[a] One peso Philippine currency equals 100 centavos equals 50 cents United States currency.

This increase of 244,401 pesos, or 61 per cent, over 1912 was due largely to the Gumaus dredge which produced almost two-thirds of the gold of the district.

Four dredges, namely, Gumaus, Maximelo, Philippine Dredging Syndicate, and Paracale No. 1, operated for the entire year of 1913, and Paracale No. 2 operated for about six months. The Malaguit Dredging Company completed its dredge in February, 1914, and the Paracale Bucket Dredging Proprietary, Limited will have completed its third dredge by April or May, 1914. The machinery for another dredge is on the ground at Paracale, and an all-steel dredge is being built in Australia. The close of 1914 will probably see at least 7 and possibly 8 dredges operating in the Paracale district.

GUMAUS PLACER COMPANY

The Gumaus dredge, according to the general manager's report for 1913, operated 5,731 hours, handled 814,500 cubic yards of dirt, and produced 10,585 ounces of gold bullion, valued at 386,352.50 pesos. The operating expenses covering all repairs, renewals, and overhead charges amounted to 119,368.25 pesos, or 14.66 centavos per cubic yard. During the year, 250,000 pesos were disbursed as dividends. The bucket pins and the screen plates had to be renewed, and the drive for the belt of the stacking ladder was changed to gearing.

The dredge was built at a point near the southern end of the property. From there it worked up a small gulch to the south as far as it could, and then returned, necessitating the rehandling of its tailings. From there it worked north, on the west side of the property, for about half a kilometer. Here the ground became too deep to be worked without an extension on the ladder, so the dredge was turned toward the south; now (March, 1914) it is operating a cut next to the one taken before.

The bedrock so far encountered is decomposed granite gneiss, except at the northernmost part of the cut, where it is somewhat harder than the gneiss and appears to be a peridotite. It is very uneven, and the depth of the alluvium is consequently very variable. This causes considerable trouble in dredging, particularly in disposing of the tailings. After passing over a shallow portion of the deposit and digging a deep portion, the dredge has difficulty in getting storage room for the material, and consequently is at times crowded up against the face.

The alluvium consists of about 1 meter of soil at the surface then from 3 to 4 meters of yellow clay, and from 5 to 9 meters of black, sticky clay, below which is the pay gravel which varies in thickness from 0.3 to 1.5 meters.

The dredge has justified expectations as to its efficiency and durability. The buckets, which were the first cast-steel buckets used in the Philippines, are very satisfactory in every respect and show very little wear.

It is claimed that about 85 per cent of the gold in the ground is saved on the tables. The largest portion of this gold is caught in the first meter of the first four tables. This has been made possible by the use of mercury in the riffles. It was necessary completely to cage off the tables with heavy wire netting and to fasten the doors leading into cages with padlocks in order to prevent robbery of the tables.

Two improvements could be made to suit the unusual conditions met with in this property. These are to lengthen the spuds so that the head of the spud would always be well above the spring blocks and to lengthen the screen to insure complete disintegration of the clay.

A serious problem now confronting the company is the fuel supply. The company was prohibited from cutting certain classes and sizes of trees by the forestry laws. Failure to observe these regulations before the native woodcutters had become familiar with them caused the company to pay a heavy fine during its first period of operation. At present the price of fuel is the largest item in dredge operation, and it is steadily increasing as near-by supplies disappear. The company is seriously considering using coal or oil as fuel for its boilers.

PARACALE BUCKET DREDGING PROPRIETARY, LIMITED

The Paracale Bucket Dredging Proprietary, Limited and the Philippines Dredges Company, Limited are very closely related. The dredges which are discussed below belong to one of these two companies. More definite information has not been secured.

The dredge known as the Paracale No. 1 was the first American dredge to operate in the Philippines. It has been almost entirely renewed, the only old portions being the winch and possibly a few smaller machines. It has a new hull, tables, boilers, bucket ladder, and bucket line. The present bucket line is made up of 5 cubic foot buckets, loose connected.

The dredge known as the Paracale No. 2 was completed about June, 1913, and has been operating since. It has 7 cubic foot buckets, close connected. A third dredge is now nearing completion. It has 8.5 cubic foot buckets, close connected. The machinery for a fourth dredge with 6 cubic foot buckets is on the ground at Paracale, and a fifth all-steel dredge with 9 cubic foot buckets is being built in Australia. It is also rumored that a sixth dredge will be built having even larger buckets.

These dredges are all of the same general type. They operate on headlines, and have no screens or stacking ladders. This practice was described in The Mineral Resources for 1912. The buckets are built up and riveted, and are much lighter than those at Gumaus. There are 2 small free-turning bucket pins on each bucket instead of one large one with a fixed end as at Gumaus and Malaguit. The actual wearing surface of each pin is about 12 square inches or 24 square inches per bucket, and this surface could not stand more than one-fourth inch wear, while the wearing surface of the Gumaus type is about 90 square inches and could stand almost one-half inch wear.

The fuel supply in Paracale is rapidly decreasing. The company is considering bringing in wood from Mambulao Bay in barges. This would seem to be a very expensive method, and merely puts off, for a time, the day when some other source of power will be required.

THE MALAGUIT DREDGING COMPANY

The dredge purchased by this company began operating on Malaguit River in March, 1914. It is a 5 cubic foot, close-connected type, with wooden hull, revolving screen, and a single bank of tables on each side. It is controlled by spuds and side lines, and has no stacking ladder. The machinery and also the main timbers which were framed and fitted in the United States were purchased from Yuba Construction Company.

The most modern improvements are represented in the digging end of the dredge in the use of a round lower tumbler and a bucket with an exceptionally broad base, thereby strengthening the bucket and reducing to a minimum the wear due to the round tumbler. Another new feature is the use of lug seats for the bucket pin on both sides of the bucket, so that the pin can be reversed when the wear on the lug seat becomes noticeable and causes wear in the front eye of the buckets. This system is said to increase the life of a bucket by about 30 per cent. These changes in the design of the bucket are not so important here, where the digging is in soft material and the wear and strain on the buckets is a minimum, but the introduction of the round tumbler should prove to be very advantageous.

The Gumaus dredge uses a 6-sided bottom tumbler. The bucket line is supposed to fit closely around this tumbler and probably does for a short time, but as the line lengthens with wear it ceases to fit the tumbler. This causes a distinct jar as the bucket forcibly adjusts itself, thereby causing a severe strain on the buckets and bucket line, as well as increasing the wear on the tumber. Is is claimed that with the round tumbler this cause of trouble is entirely eliminated on that end of the ladder.

Specifications for the Malaguit dredge provided by Yuba Construction Company are on file in the Bureau of Science.

MAXIMELO DREDGING COMPANY

The Maximelo dredge operated during the entire year, and produced 75,403.75 pesos' worth of gold. It handled a greater yardage than any company in the district except the Gumaus.

THE PARACALE VENTURE COMPANY

Very little work was done on this property during the year. A second shaft was put down and cased with steel, and 204 pesos' worth of gold was taken out.

TUMBAGA

The Tumbaga mine has been reopened under the direction of Mr. La Duc and Mr. Dudley. They have carried on development work and have recovered the vein which was displaced by a fault.

The old mill has been moved to a new site, and should be in operation by May, 1914.

THE AROROY DISTRICT, MASBATE

By WARREN D. SMITH

The mining operations of the Aroroy district have been discussed each year in this publication, and a discussion of the geology by H. G. Ferguson, with a geologic reconnaissance map of the district, has been published.[1] As this district has lately taken first rank among the gold fields of the Archipelago and bids fair greatly to surpass the others, it is but proper to give it special attention at this time.

There are remains of mine workings in various parts of the Aroroy district which have the appearance of great age. Whether these represent the activities of Chinese before the Spanish conquest or are of a later period cannot be definitely ascertained.

One of the first Americans to direct attention to the district was Mr. August Heise, who prospected in the vicinity of Aroroy in 1903.

In 1904 and 1905 attempts were made to boom the placer prospects on Guinobatan and Lanang Rivers, but although two dredges were installed these attempts never realized anything other than what resulted from the sale of stock. One dredge was destroyed in a typhoon, and the other was later dismantled and transferred to the Paracale district.

In 1907 a small stamp mill was erected on Guinobatan River a short distance above the present Syndicate Mining Company's mill site. This mill belonged to the now defunct Eastern Mining Company. At that time it was unsuccessful, and the holdings of that company were later taken over by the Syndicate Mining Company, which started mill operations on February 1, 1914.

In 1911 a 20-stamp mill of modern design was erected on the claims originally located by Mr. Herbert on the north bank of Guinobatan River about 2 kilometers below the old Eastern mill. This mill has been running steadily ever since, and is perhaps the most consistent gold producer in the Archipelago. This is the Colorado property.

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[1] *Phil. Journ. Sci., Sec. A* (1911), **6**, 397.

Fig. 1. Clearing the mill site prior to construction.

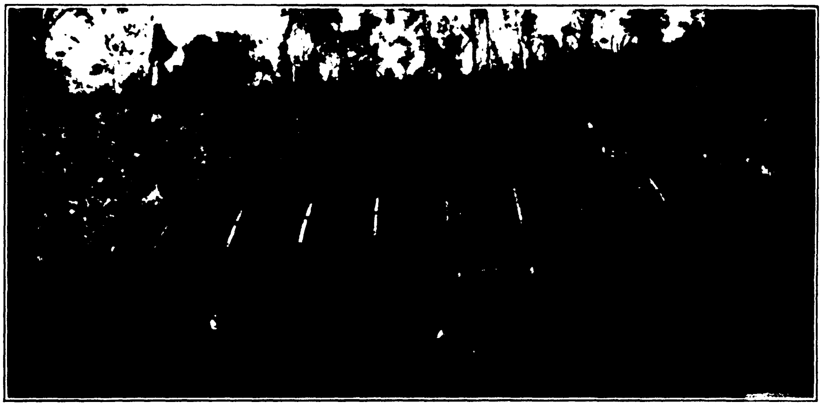

Fig. 2. The mill during erection.

Fig. 3. The completed mill.

VIEWS OF THE KEYSTONE MILL, AROROY, MASBATE.

In 1913 the Syndicate and Keystone properties each erected mills; these were fully described in The Mineral Resources for 1912.

The principal rocks in the district, in the order of abundance, are andesite, pyroclastics, quartz diorite, small amounts of limestone, and alluvium.

On the west side of Port Barrera is a large area of sediments of late Tertiary and Pleistocene age. These dip gently to the southwest. Presumably at one time they overlapped the igneous core to the east and possibly extended over the whole area in the form of a broad arch. This assumption seems to be borne out by the remnants of limestone found on the top of the igneous rock in one or two localities. A reference to Ferguson's map shows that one of these remnants is found on Aroroy Mountain and furnishes lime for the cyanide plants near by.

To the east of Ambulong Peak (which is near Aroroy barrio), there is a fair-sized area of quartz diorite, and it is believed that considerable mineralization will be found in the neighborhood of that formation as in the case of the Benguet district where the best values so far have been found.

Many who have visited this district have noted a strong system of veins striking northwest and southeast, which, however, is considerably interrupted, apparently faulted, and offset laterally.

This faulting makes it seem as if there were a greater number of veins than really exist.

The Hayes property.—This property is situated in the extreme southern part of the district. Mr. Hayes, one of the first prospectors in the district, is running some crosscuts in an attempt to intersect the southeastward extension of the main lode of the district which is locally known as the Broncho lode. His work has not yet proceeded far enough to establish the value of his venture.

The Schwab property.—The next property to the north of Mr. Hayes's property and on the south of Boston Hill is being worked by Mr. Schwab, who is now running through about a ton of ore a day in a small 1-stamp mill. He and his associates expect to install a 5-stamp mill in the near future and have most of the plant on the ground. It is claimed that the best free-milling ore in the district is found here.

The Syndicate property.—I visited the Syndicate property at the time that the new plant was completed, and saw the machinery running. The plant was giving entire satisfaction, although no ore had yet been treated. This plant was described in last year's Mineral Resources. Recent work in the mine shows that the property has considerable merit, and as there is now a very fair supply of ore ahead there seems to be no reason why the property should not enjoy a very successful career. There are three very distinct grades of ore in this mine: A soft, much-oxidized ore near the surface, which apparently has been considerably enriched by descending waters; a fairly hard quartz ore which carries very good values; and a calcite vein which is not so rich. It seems pretty clear that there has been considerable secondary silicification of the veins on this property as well as in other parts of the district, and this has affected the country rock between the veins, making it appear as if there were but one large vein, whereas in reality there are several smaller veins, more or less parallel, with silicified and much-altered country rock between. Faulting with lateral throw of these veins might easily make it appear that there is a much wider vein than really exists if the workings should cut the vein at just the right angle near one of these faults.

The Colorado mine.—From all that we can learn, the Colorado mine continues its steady production. As the representative of the Bureau of Science was refused admission to the mine and mill, no further statement can be made.

The Mount Cogran Mining Company.—There is no work being done on the Mount Cogran Mining Company's property.

The Gold Bug property.—No work is being done on the Gold Bug property, and the mill has been almost entirely dismantled.

The Keystone Mining Company.—This property, which is situated in the northernmost portion of the district, a short distance from Aroroy barrio, has been run for several months. While some difficulties have been experienced at the mill and adjustments of machinery have been necessary, fairly consistent progress is being made. This property has an excellent site, and has apparently a considerable supply of ore ahead. Pannings of the ore are exceptionally good, and the results of the pannings have been confirmed by assays.

The three mills, Syndicate, Colorado, and Keystone, with their entire different types of machinery, afford excellent opportunities to compare their relative efficiencies. As has been mentioned in previous articles, in the Syndicate mill the ore is run through crushers and through ball and pebble mills; at the Colorado, stamps are used; and at the Keystone, Lane slow-speed mills.

Many improvements have been made in the district, chief among which are a new road from Aroroy to the southernmost

Fig. 1. A view of the mill nearly completed.

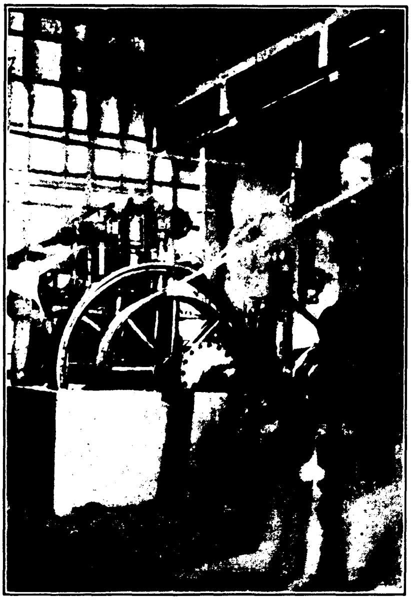

Fig. 2. A corner of the mill, showing Diesel engine used for power.

Fig. 3. A section of the 3-rail tramway from mine to mill.

VIEWS OF THE SYNDICATE MILL, AROROY, MASBATE.

large mill—the Syndicate—and a branch from this road running to San Augustin Bay, where landings have been made for the Colorado and Syndicate properties. There is now an excellent steel bridge over Lanang River, and there is a schoolhouse on the Colorado property for the children of the mining population. Boats between Manila and Aroroy make more regular runs than formerly, and there are telephonic and telegraphic communications. The district is in a flourishing condition, and prospects are very promising for successful operations for many years to come. There are many unprospected veins on the properties of the three operating companies which may prove to be of workable value.

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OTHER MINERAL DISTRICTS

By F. T. Eddingfield

Baguio mineral district.—The Headwaters mine under the direction of Smith, Bell & Co. operated for six months during 1913 and produced 75,281 pesos'[1] worth of bullion. This apparently included some values from 1912 ore. The ore mined and milled in 1913, while working 60 per cent of the time, was 3,631 tons valued at 73,825 pesos, from which were recovered 58,996 pesos of bullion, an extraction of 80 per cent. The average cost of mining for five months in 1913 was 6.31 pesos per ton. The cost data of mill operation are given in Table I.

TABLE I.—*Cost data of mill operation, Headwaters mine.*

	Pesos per ton.
Amount recovered from ore	16.26
Native labor	1.17–1.49
White labor	0.66–1.15
General expense	0.38–0.81
Motive power (February, March, and April)	1.87–2.71
Cyanide	0.34–1.71
Zinc	0.32–0.46
Chemicals	0.02–0.07
Sundries	0.27–1.65
Repairs	0.05–1.30
Lime	0.24–1.41
Total average cost for six months	6.77

The mill was operated entirely by water power for about eight months of the year. From February to June the water was too low to furnish power, and gasoline engines were used.

The total cost of 13 pesos per ton for mining and milling is excellent work considering the small tonnage mined, and is about equal to the cost per ton of other mines in the Islands, which produce nearly five times as much ore.

The only reason that this mine has not established itself as a consistent producer is that development work has not been carried on sufficiently in advance of mining operations. This was an error in the beginning which cannot be attributed to operators who took charge later.

[1] One peso Philippine currency equals 100 centavos equals 50 cents United States currency.

The Camote mine, a small though consistent producer, has operated steadily for several years with a small stamp mill and produced annually from about 8,000 to 10,000 pesos.

The Benguet Consolidated has not been operating for over two years, but negotiations are now on foot to erect a mill and reopen the mine.

The operations of Messrs. Ebert and Probeck, who had a 3-stamp mill with amalgamation plates, were cut short by a landslide which caused so much damage that they were unable to continue.

Mr. Horr, who for years has been in charge of the Ascension group of claims, has transferred the old 3-stamp mill from the Hartwell claims to the Ascension claims. He is erecting the mill himself with practically no outside assistance. Mr. Horr claims to have a manganese vein which contains good values in free gold.

Mr. Clinton Hulbert, formerly associated with the Major mines, has been prospecting some veins on Batwaan Creek. One of these veins is about 1 meter wide, but is of such strength that it can easily be traced on the surface for about 300 meters. The ore is of good value and in places is remarkably rich in free gold. Mr. Hulbert is now erecting a stamp mill on this property, which he intends to run by water power. This should be easily done as conditions are very favorable. The chief disadvantage of this location is its distance from good transportation routes.

The remaining groups of claims in this section of the Baguio district are in about the same condition as in years past. A little development work has been done, but no new findings have been reported.

Some activity has been in evidence in Bued River Valley, where two or three veins have been discovered carrying good values in free gold. One of these has been mined by Igorots under the direction of Mr. Humphreys, and has produced a noteworthy amount of gold.

Lubang district.—Mr. Cook, formerly associated with a mine on Marinduque, has recently moved the 3-stamp mill from there to a property in the Lubang district, southern Benguet. The ore in the Baguio and Lubang districts is similar in many respects. One or two veins are reported to be rich in free gold, but the majority of the ores, while showing high assay values, contain so large a percentage of sulphides as to make the recovery of values a serious metallurgical problem.

Umerai district.—The dredge of the Umerai Gold Limited has been landed on the property and should be in operation soon. An option has been granted another company to work the black sands along the beach, and a metallurgist has been sent from Australia to investigate their economic possibilities. It is claimed that a new method has been devised whereby the values in black sand can be economically extracted.

Prospecting is being carried on in the mountains southwest of this district by Mr. E. Heise and Mr. Kent, and good findings have been reported.

Marinduque district.—Two prospectors are investigating the lead-silver-gold deposits southwest of Santa Cruz, Marinduque. Large areas have been found covered with galena "float." It is said that there is a remarkably large number of gold-bearing quartz as well as galena veins in this district.

Cansuran district.—The Cansuran Mining Company is installing a hydraulic plant to work its placer holdings. This district should be producing before the end of the year. Some quartz veins have been discovered which may develop into workable deposits.

Agusan River district.—Testing is still being done along the Hibong River placers. It is understood that Mr. A. Heise is now in the United States on business connected with this property. An examination of some placer ground north of this property was made by Mr. B. Warner Rice, who reported payable values.

THE BULACAN IRON-ORE RESOURCES

By Wallace E. Pratt

PRODUCTION OF IRON IN 1913

The iron-ore resources of the Philippines have been accorded more attention during the past year than at any previous time since American occupation. The smelting of iron ore by the primitive native method has continued, and the production of cast iron for 1913 is greater by 60 per cent than that of the previous year, which in turn had been a record breaker for the industry. No radical changes in the native smelting process are recorded for the past year, but a tendency to experiment by slight modifications of the old method is manifest. Several furnaces have been charging a little limestone with the ore as a flux. It is to be questioned if any good results from this innovation, however, because limestone alone is not a sufficient flux for the average ore and its presence interferes with the reactions of the established method.[1] Some of the smelters have been able to utilize ores containing only 50 per cent metallic iron, but in most cases the lean ores are enriched by additions of scrap iron. Two corporations composed largely of Filipinos have entered the Angat district prepared to exploit their respective holdings by modern methods.

The importation of pig iron during the twelve months ending June 30, 1913, according to the records of the Collector of Customs, amounted to 1,204 metric tons valued at 50,908 pesos.[2] The imports of iron and steel, including only bars, rods, rails, and structural material, amounted to 23,706 tons valued at 1,841,868 pesos.

[1] It has been stated that the Angat ores are self fluxing. This is not the case; every native furnace is lined with a certain residual clay, which together with the tuyere made of the same clay fluxes the ore and is rapidly consumed and frequently replaced.

[2] One peso Philippine currency equals 100 centavos equals 50 cents United States currency.

The value of the cast iron[3] produced in the Philippines in 1913 was 64,471 pesos. Table I shows the quantities of iron ore smelted, the quantities of iron produced, and the value of the product since the beginning of the industry in 1664.

TABLE I.—*Total production of iron ore and metallic iron and value of the iron produced in the Philippine Islands.*

Year.	Iron ore.	Cast iron.	
	Met. tons.	*Met. tons.*	*Pesos.*
1664 to 1883	[a] 8,000	2,500	350,000
1884	600	230	25,040
1885 to 1901	[a] 2,000	600	70,000
1902	160	56	6,400
1903	200	70	15,900
1904	350	123	20,170
1905	320	116	18,400
1906	350	125	18,000
1907	380	132	19,536
1908	290	96	17,500
1909	234	78	31,078
1910	150	50	20,023
1911	219	73	29,159
1912	352	141	49,272
1913	555	227	64,471

[a] Estimated.

The records show that the native iron-smelting industry was larger in 1884 than it is to-day. Although statistics are not available for the earlier years, it is a matter of record that native iron smelters have been in desultory operation throughout the last two hundred fifty years and that smelters were formerly operated at Morong and Santa Inez in Rizal Province, as well as in Bulacan Province to which the industry has been confined since American occupation. In 1884 the center of the Bulacan industry was at Camaching in the municipality of San Miguel, when 5 furnaces were in operation which produced 30,000 pairs (*pares*), while the mines nearer the town of Angat had 4 furnaces only and produced but 28,000 pairs. During 1913 only 1 furnace was in blast at Camaching while 9 furnaces were in operation around Angat. Table II contains detailed information concerning the operation in 1913. The data are of interest, in that they bear on a purely native industry and upon a primitive metallurgical process.

[3] The product of the native smelters is cast directly into cast-iron implements, principally points and shares for the native plow. No pig iron is produced. For a description of the smelting process see *Phil. Journ. Sci., Sec. A* (1913), **9**, 201.

TABLE II.—*Statistics of iron smelting in 1913.*

Furnaces in blast		10
Smelting runs (*cendidas*), all furnaces		61
Days in blast, all furnaces		657
Ore used	tons	555
Calculated weight of iron in ore [a]	do	333
Charcoal used	do	960
Average length of furnace run	days	11
Days in blast; average for each furnace for the year		66
Pairs per day in blast, average		86
Kilos per day in blast, average		345
Ore required per ton of iron obtained	tons	2.45
Charcoal used per ton of iron obtained	do	4.23
Efficiency of native process	per cent extraction	68
Value of product per ton	pesos	284

PAIRS [b] PRODUCED.

	Pairs.	Kilos.	Pesos.
First class	12,440	40,400	13,684
Second class	9,147	36,600	13,720
Third class	12,006	36,000	12,006
Points	22,783	113,700	25,061
Total	56,376	226,700	64,471

[a] Average analysis of ores shows Fe = 60 per cent.

[b] A first-class pair (pare) consists of a single large plowshare which weighs about 3.2 kilograms. The second- and third-class pairs each consist of 2 smaller plowshares; a second-class pair weighs 4 kilograms and a third-class pair weighs 3 kilograms. Two points constitute a pair, and each point weighs 2.5 kilograms.

THE ORE DEPOSITS

The Bulacan iron-ore region lies in the foothills of the eastern cordillera about 15 kilometers east of the towns of Angat and San Miguel, Bulacan Province. The region has its major extension in a north-northeast direction. Numerous isolated outcrops are found for a distance of 20 kilometers along this line, over a width of about 2 kilometers, and two small outcrops occur to the east of this general belt.

GEOLOGY

The geology of the ore deposits has received but little attention. H. D. McCaskey [4] studied the iron-ore region, but was concerned principally with the Filipino metallurgy and with a survey of the region. Smith visited the Bulacan smelters several times, and published notes on the geologic relations of the ores with a suggestion as to their genesis.[5]

[4] *Bull. P. I. Min. Bur.* (1903), No. 3.

[5] *Min. Resources P. I. for 1909* (1910), 33; *ibid. for* (1911), 57.

The ores are found near the contact of the igneous rocks, both holocrystalline deep-seated rocks and intrusives and extrusives which form the cordillera, with the sedimentaries lying more or less tilted, on its western flank. The strike of the sedimentary formation is roughly parallel to the line of contact with the igneous rocks. The upper beds are tuffs, clays, and sands of Pleistocene to Recent age, while the lower part of the series is made up of the shales, sandstones, and arkoses which Smith [6] assigns to the Miocene and Oligocene. The limestone horizons which have been noted generally in the Tertiary rocks are identified in this series, and at several places there is an apparent association [7] of the ore deposits and the lower limestone (Oligocene).

Along the contact of the sedimentary and igneous rocks in the region of the ore deposits for a distance north and south of perhaps 15 kilometers the lowest stratified rocks lie upon a holocrystalline rock containing principally quartz and feldspar with subordinate decomposed hornblende, which is classed megascopically as a granite. The granite exposure is roughly lens shaped, the width at right angles to the line of contact being only from 2 to 3 kilometers. To the east of the granite area are andesitic flows and fragmental rocks. Both the granite and the extrusives are older than the sedimentaries, the basal members of which are made up of the erosional products of the igneous rocks. Dikes and small intrusions, most of which are basic in character, penetrate the granite and the older effusives. A younger series of rocks includes agglomerates, flows, and dikes which are interbedded with or which penetrate the sedimentaries. The dike rocks are dark colored and fine grained; probably both andesites and their holocrystalline equivalents are represented. The relations of the iron-ore deposits to these various classes of rocks are not worked out in detail, but the broader associations are noted briefly in the discussions of the individual mining centers.[8]

THE ORES

The ores are essentially hematite and magnetite. These minerals occur as intimate mixtures in all proportions from pure magnetite to pure hematite, although hematite is more com-

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[6] *Phil. Journ. Sci., Sec. A* (1913), **8**, 235.

[7] That the association of the ore deposits with sedimentary rocks has not been noted earlier is due to the difficulty of geologic correlation in an unmapped and imperfectly explored tropical region.

[8] The Philippine Journal of Science, *loc. cit.*, contains in more detail the results of the studies upon which this article is based.

monly encountered. The ores are usually fine grained and massive, but the hematite is sometimes "micaceous." The hematite ores are hard and dense, while the magnetite and the typical hematite-magnetite ores are softer. Quartz is prominent in most of the ore; it generally occurs filling interstices between the iron minerals, but considerable vein quartz carrying only minor quantities of crystalline hematite and magnetite is to be observed. Great bowlders and blocks of iron-stained quartz mark the immediate neighborhood of the ore bodies. The quartz in these bowlders is evidently the product of the replacement of other rocks by silica. The walls of the shallow pits from which the iron ore is mined are in many instances a soft, dark green rock, which consists largely of hornblendic mineral, sometimes fibrous, but usually massive. It is probable that this rock is in some degree analogous to the complex silicates which are characteristic of some of the Scandinavian iron ores and to which the name "skarn" has been applied by the Swedish geologists.[9] The association of the ore with this wall rock is so general that the native miners recognize the latter as *camisa de bacal* (cloak of the iron ore). Pyrite is characteristic of the ores, and occurs in them as aggregates of fresh crystals or massive in veinlets. Chalcopyrite sometimes accompanies the pyrite, and cobalt has been detected in these sulphides.

Analyses show the ores smelted in the native industry to average 60 per cent or more of metallic iron. The ore is hand picked for smelting, however, and since the miners are very clever at judging rich ore the smelting charges represent better than the average ore. Samples made up of spalls from many bowlders on the outcrops indicate that the larger ore bodies carry on an average from 50 to 55 per cent of metallic iron. The typical ore is of Bessemer grade although in some of the ores the phosphorous content is above the usually prescribed limit; sulphur is generally low. In the purer ores the percentage of alumina (from 2 to 6 per cent) is rather high in proportion to the silica (from 3 to 8 per cent). Alumina and silica are the principal slag-forming constituents of the ores.

DESCRIPTION OF THE INDIVIDUAL ORE DEPOSITS

Camaching.—The iron-ore deposit in the locality called Camaching at the head of Balaong River lies about 20 kilometers north-northeast of Angat. Camaching is the northernmost of the iron-ore properties in the Angat district and is also the most

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[9] *Trans. Am. Inst. Min. Eng.* (1907), **38**, 766.

difficultly accessible property. There is displayed at Camaching, however, a tonnage of iron ore greater than that of all the other properties combined.

The ore body is at the eastern edge of an area of steeply tilted, stratified rocks, principally tuffs and tuff-sandstones, whose dip is to the west. The ore deposit appears to mark the base of the series. The outcrop strikes north 20° east in conformity with the overlying sediments, and can be traced over a length of 600 meters; its exposed width is from 20 to 70 meters throughout this length.

Magnetite is the principal ore mineral, but is intimately mixed with black massive hematite. The furnace charge carries 62 per cent of metallic iron. Quartz and pyrite are characteristic gangue minerals, together with the minerals which make up the typical wall rock already described. Marble or crystalline limestone is closely associated with the ore, and small veins of magnetite and black hematite cutting limestone are to be observed, as are also blocks or horses of limestone in the ore. In parts of the footwall red hematite occurs which is calcareous and appears to be a replacement of limestone. In the vicinity of the ore body the bedded rocks are cut by dikes of a dark-colored felsite, and to the east similar rocks appear at the surface, occurring as extrusives. It is probable that the ores are genetically related to these intrusive dike rocks.

An accurate estimate of the ore reserves at Camaching is not possible, owing to the lack of underground development. A conservative approximation may be arrived at, however, by considering the area of the outcrop to be 600 by 20 meters and assuming that the ore will continue to a minimum depth equal to its least surface dimension. In view of the probable deep-seated origin of the deposit, such an assumption appears to be reasonable. The average specific gravity of the ore is 4.7, consequently an estimated reserve of 1,100,000 metric tons results from the assumption that the ore continues in depth to a distance equal to its average outcrop width.

Montamorong.—Montamorong lies about 7 kilometers south-southwest of Camaching. It is nearer the western edge of the cordillera than Camaching, and is, consequently, more accessible. The ore deposit at Montamorong occurs at the eastern edge of the granite area on the contact between the granite and extrusive rocks—flows and tuffs. Numerous dikes of a dark-colored holocrystalline rock made up principally of plagioclase feldspar and pyroxene cut both the granite and the extrusives in the vicinity of the ore body. The ore body has the appearance of a vein with much-altered and not sharply defined walls. A shallow pit which has been opened on the outcrop reveals the presence of a fault parallel to the apparent strike of the vein (north 60° west) with a downthrow of about 1 meter to the northeast. The vein pitches to the northeast at an angle of 45° at the site of the pit, but it is doubtful if the strike and pitch, as noted, are constant. The workable ore in the vein has an estimated thickness of from 1 to 2 meters, and the outcrop can be followed for 50 meters.

The ore is a soft massive hematite with a considerable quantity of magnetite. Smelting charges carry nearly 62 per cent metallic iron. Quartz and pyrite are the principal gangue minerals, but the walls of the vein, which are ore bearing, consist principally of the usual greenstone. The extrusive rocks to the east of the ore deposit are almost wholly replaced by silica, and the determination of their original character is difficult. The evidences of silica-bearing waters as accompanying and perhaps following the deposition of the iron ore are widespread.

The tonnage of available ore at Montamorong is undetermined. The ore reserves here are apparently much smaller than those at Camaching, however.

Hison.—The original Hison concession, the demarcation for which was performed in 1816, apparently centered around the middle one of three outcrops which occur about 3 kilometers south-southeast of Montamorong. The Santa Lutgarda claims were located in 1876 on an outcrop just south of Hison, and in 1880 the Constancia claims were granted on an outcrop just north of Hison. These three outcrops are on a line which trends about north 20° east, and the strike of the ore body at each outcrop is likewise north 20° east. The distance from the Hison to the Santa Lutgarda outcrops is 300 meters, and from the Hison to the Constancia outcrop nearly 500 meters, making the distance between the Santa Lutgarda and Constancia outcrops about 800 meters. The outcrops have been uncovered by three small parallel streams, affluents of Maon Creek, which lies to the east. While the iron cannot be followed across the high ridges between these streams and the ore body may not be continuous through the ridges, the outcrops are unquestionably closely related.

These outcrops lie along the eastern border of the granite area. Immediately east of the Hison outcrop is a narrow belt of sedimentary rocks, consisting of limestone, shales, clays, and fine-grained clastic rocks. The limestone is most prominent, and persists southward beyond the Santa Lutgarda outcrop. The beds strike north 20° east, and dip eastward at an angle of 60°. As at Montamorong the periphery of the granite is cut by dikes which appear to penetrate the sedimentaries as well. Although detailed relationships cannot be determined, in a general way the Hison ore deposit occurs between a basement of granite and overlying sedimentaries and is associated with the dike rocks.

At Hison and Santa Lutgarda the ore is identical; at the surface, a massive hard black ore consisting of both hematite and magnetite, while in the shallow pits which have been opened the ore encountered becomes softer and consists almost exclusively of magnetite. Smelting charges carry 65 per cent of metallic iron. Gangue minerals are quartz, pyrite, and the minerals of the characteristic green rock which is found in and near the walls. At the Constancia outcrop the ore is similar, but carries less quartz and a larger proportion of the green wall rock, which here is lighter than usual in color and decidedly fibrous.[10] The Constancia ore is principally magnetite with subordinate black hematite. It is soft, and is marked by nests and veinlets of pyrite. Here, as elsewhere, the pyrite is most prominent near the walls of the deposit.

In the bowlders which mark these outcrops, several thousand tons of ore are available. The width of the ore exposed in the outcrops varies from 6 to 15 meters, but it cannot be assumed that the deposit is continuous between outcrops.

Santol.—Two mining claims located by American prospectors cover the base of Mount Santol along Santol Creek about 3 kilometers south-southwest of Hison. No outcrops of ore in place are to be seen, but the claims are strewn with large hematite-magnetite bowlders aggregating undoubtedly several thousand tons of ore. The bowlders are confined to the lower third of Santol Mountain, which rises some 170 meters above the level of Santol Creek. The longer axis of the bowlder-covered ground is directed northeast and southwest and is 300 meters long. In contrast with Hison and Montamorong along the eastern edge of the granite the Santol ore lies on the western border of the granite area and near its southern end. A few hundred meters west of the bowlder-strewn hillside are the westward-dipping

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[10] This rock as it occurs at Constancia has been studied in thin section by F. T. Eddingfield of the Bureau of Science, and the principal component mineral has been identified as tremolite.

limestone, shale, sandstone, and fine conglomerate which flank the cordillera. The base upon which the beds lie and upon which also most of the bowlders of ore are found is extrusive material—flows, agglomerates, and tuffs. Farther east, but still among the ore bowlders, the granite appears, only to be covered again a short distance beyond by limestone still dipping to the west and striking north 20° east. In the granite and the extrusive rocks are found the usual fine-grained dikes.

There are hematite-magnetite ore deposits at Tumotulo, which lies wholly within sedimentary rocks, about 3 kilometers south-southwest of Santol, and marks the southern end of the iron range as far as is known at present; at Macatalinga and Tagpis, 6 and 10 kilometers, respectively, east of Hison; and at Bulac near Montamorong. These places are of less importance than those already described, and with the exception of Tumotulo they do not afford any additional data on the ore deposits. Only insignificant quantities of ore are exposed at any of the minor deposits, although at Macatalinga and Tumotulo more ore might be encountered if large open cuts were excavated. The ore at Tumotulo is found near a small dike in the sedimentary rocks. It contains 9 per cent of titanium, a circumstance which is suggestive as to its genesis, in view of the general belief that titaniferous magnetites are in many cases magmatic segregations. None of the other Bulacan ores carries an important proportion of titanium.

GENESIS OF THE ORES

The inevitable and intimate association of the ores with vein quartz and the character of this association suggest that the ore minerals, hematite and magnetite, were deposited together from solutions presumably of more or less deep-seated origin. Part of the pyrite occupies cracks in the original ore and must, therefore, be secondary, but pyrite and rarely chalcopyrite also occur in intimate mixture with the ore minerals apparently as original constituents of the ore. Much of the ore appears to be a product of replacement; specimens showing the replacement of limestone, fragmental rocks, felsites, and holocrystalline rocks by ore have been noted. The green wall rocks, which have been cited as comparable with the "skarn" of the Norwegian iron-ore deposits, are believed to be an alteration product resulting from the action of the ore-depositing solutions.

The principal ore deposits occur near contacts between sedimentary and older igneous rocks, both deep seated and effusive. The strike of the contact between the igneous rocks and the sedimentaries, which is in general parallel to the strike of the sedimentary rocks, is also the strike of the larger ore bodies. The possible conclusion from this fact that the ore has resulted from contact phenomena between the two types of rocks is not tenable, however, because the igneous rocks are not intrusive but constitute a preëxisting basement.

The contact may have afforded lines of weakness, however, which were favorable avenues of ascent for subsequent intrusions, and the ore may have been formed by mineral-carrying solutions which accompanied or followed these intrusions. The dike rocks observed near the ore bodies probably represent the intrusions which thus controlled the mineralization. Parts of the intrusions were undoubtedly inserted along the bedding planes of the sedimentary rocks, and consequently the ore resulting from such intrusions appears to be interbedded with the sedimentaries.

The conclusion that the ores have resulted more or less directly from contact phenomena is supported by the occurrence of original sulphides, pyrite, and chalcopyrite in the quartz with magnetite and hematite, in as much as such association is held by W. Lindgreen [11] to be the one unique characteristic of contact deposits. The typically contact minerals, garnet and wollastonite, were not observed in these ores, although particular search was made for them, but the presence of tremolite and other metamorphic minerals in the rocks is evidence of the contact origin of the ores.

PRACTICAL SIGNIFICANCE OF THE SUGGESTED MODE OF ORIGIN

From the foregoing discussion it will appear that a minimum of 1,000,000 tons of iron ore is probably available in this field. This approximation is made in the absence of any direct information as to the persistence of the ore with depth, and is therefore not to be accepted as a reliable estimate. If the deposit is purely superficial, as it may well be, so far as the evidence from exploration is concerned, then the estimate is too large. From the geology of the deposits as presented in this paper, however, it may be argued that the persistence of the ore to a reasonable depth is probable, and if the ores do persist in depth a great deal more than 1,000,000 tons should be in reserve in this field.

Other observers have suggested that the Bulacan iron ores have resulted from the alteration of pyrite and other iron-bear-

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[11] *Trans. Am. Inst. Min. Eng.* (1901), **31**, 277.

ing minerals by surface waters. Such an alteration would be most complete at the surface; therefore, the ore might be expected to become more pyritiferous with depth and to be unfit for use when the unchanged sulphides were reached. A deep-seated origin, such as is suggested in the foregoing discussion, with the pyrite secondary or at most contemporaneous in origin with the ore minerals, would mean more constancy in character with depth and a more or less uniform distribution of pyrite.

It would not be difficult nor expensive to explore the Bulacan iron-ore deposits by core drilling and thus to determine their character and extent beneath the surface.

COAL MINING IN 1913

By WALLACE E. PRATT

No commercial production of Philippine coal is recorded for the year 1913. The mine at East Batan, which produced from 20,000 to 30,000 tons annually from 1909 to 1911, has remained closed since August, 1912. The surface plant has recently been dismantled, and the mine is practically abandoned. The United States Army mine at Liguan on the west end of Batan Island is in charge of a caretaker and is not in operation.

The following data as to the condition of the East Batan mine at the time it was abandoned were obtained from Mr. C. N. Orr, who has acted as superintendent at the mine since it was taken over by the Government of the Philippine Islands.

The coal bed lies inclined at an angle of 18° from the horizontal. The main slope was driven down from the outcrop diverging to the left from the line of dip so as to bisect, approximately, the angle between the lines of dip and strike. The coal was mined from rooms driven up the dip from butt entries which followed the strike on each side of the main slope. The outcrop of the bed is covered by the sea a short distance southeast of the mouth of the slope, and practically all the mine workings are below sea level.

The main entry had been driven a total distance of nearly 500 meters, but was caved for some distance from the face. Entries 1, 3, 5, 7, and 9 had been driven to the left, and entries 2, 4, and 6, to the right. Entries 1, 3, and 5 had been sealed off by concrete bulkheads in an attempt to smother a mine fire which started in 1911. Entry 7 had advanced 700 meters to the left, but was abandoned because of a change in the character of the seam; near the face the coal became very dirty and large balls of pyritiferous mud were encountered in it. On entries 2 and 4 all the rooms had been worked out and the pillars drawn. The rooms on entry 6 were being mined, and a new main slope had been started, advancing up the dip from near the face of this entry. This new slope was designed to improve conditions by removing operations farther from the part of the mine which was on fire, by obviating the necessity of turning off butt entries at awkward angles (135° and 45° with the haulage way), and by making it more convenient to utilize the full slope of the coal bed in getting the coal down out of the rooms.

Unfortunately, as the new slope advanced toward the outcrop, it penetrated loose, broken ground and salt water began to enter the mine. It became evident immediately that the water was coming directly from the sea, and although the face was bulkheaded off with concrete the slope had to be abandoned. Shortly afterwards the pumps and rails were removed and the mine was closed. Mr. Orr, together with other engineers who are acquainted with the character of the roof and floor at Batan, believes that the attempt to unwater and reopen the old workings would be more expensive than to develop a new mine on the coal.

There is at present no activity in coal mining except on Cebu. Systematic exploration under the direction of the division of mines of the Bureau of Science has been in progress throughout the last year in the Uling field in central Cebu, and the possibilities of this field will be pretty definitely known within a few months. The data which have been obtained during this exploration will ultimately be made public and will be valuable in connection with the exploration of other districts.

According to the annual report of the Collector of Customs, imports of coal during the fiscal year ending June 30, 1913, amounted to 459,583 metric tons, with a value of 2,393,918 pesos.[1] About 65 per cent of this importation came from Japan; the balance, except an insignificant quantity, came from China and Australia. The imports of coke amounted to 11,572 tons, worth 86,034 pesos. The Manila Gas Company manufactures coke in small quantity (about 1,000 metric tons per annum) as a byproduct, using Australian coal. Coal retails at from 12 to 15 pesos per ton locally; coke sells for from 30 to 60 pesos per ton. Manila "gas house" coke is offered at the former, while the best Connellsville coke is quoted at the latter figure.

[1] One peso Philippine currency equals 100 centavos equals 50 cents United States currency.

PHILIPPINE PRODUCTION OF NONMETALS IN 1913

By WALLACE E. PRATT

TABLE I.—*Quantity and cost exclusive of transportation of nonmetals produced in 1913.*

	Quantity.	Value.
		Pesos.[a]
Coal[b] metric tons	-----------	-----------
Clay products	-----------	460,000
Lime metric tons	11,050	102,700
Sand and Gravel cubic meters	689,001	595,645
Stone do	197,039	350,041
Salt metric tons	19,500	575,000
Mineral waters liters	270,000	60,000
Total	-----------	2,143,386

[a] One peso Philippine currency equals 100 centavos equals 50 cents United States currency.

[b] No commercial production during 1913, although several hundred tons were mined in the progress of exploration work in Cebu.

Coal.—The status of the coal mining industry in 1913 is discussed on page 32.

Clay products.—All clay products are manufactured by native methods, the principal types of ware produced being pots for cooking rice; water jars and bottles; sugar *pelones*, large conical vessels used in native sugar making; vitrified jars, from 20 to 100 liters in capacity, which are used as containers for various purposes; common bricks; flat tiles, *baldosas;* and flower pots.[1]

Lime.—The demand for lime is steadily increasing, and if the entire consumption could be supplied from a single manufacturing center an industry of considerable proportions would result. Lime is used in the Philippines principally for the clarification process usually employed in sugar manufacture. Over 200,000 metric tons of sugar were produced in 1913, the manufacture of which would consume more than 3,000 tons of lime according to standard practice. The sugar producers in Negros, where the industry centers, obtain their lime from Guimaras Island, paying

[1] For a description of the methods of manufacture, the reader is referred to an article on Philippine pottery in *Phil. Journ. Sci., Sec. A* (1910), 5, 143.

from 6 to 7 pesos a ton at the kiln for air-slacked lime of poor quality. The annual consumption of lime in and around Manila is reported to be about 7,500 tons, worth 9 pesos per ton. The larger part of the lime for the Manila market is made by calcining sea shells collected along the beaches. During the year 1914 the consumption of lime for neutralizing solutions in the cyanide mills at Aroroy, Masbate, will approach 1,000 tons.

Sand and gravel.—Sand and gravel are used as construction materials and in road building, and are obtained locally throughout the Archipelago. The Manila Gravel and Gold Dredging Company, Limited, which claims practically the whole valley of Mariquina River as placer-mining property, plans to control the Manila market as soon as its dredge can be erected. The sand and gravel from Mariquina River are superior to the Pasig River product, which is the only other readily available supply, and would, therefore, be preferred at an equal cost. The estimates in the prospectus of the new company base the operation on an annual sale of 65,000 cubic meters of gravel at 2.18 pesos per cubic meter, 65,000 cubic meters of clean sand at 1.44 pesos per cubic meter, and 65,000 cubic meters of filling material at 97 centavos per cubic meter. From the records kept by the Bureau of Science during the past five years, it appears that the total annual consumption in and around Manila is somewhat greater than the quantity which this company proposes to market. Prices vary considerably; during the past year a dredge now operating on Mariquina River delivered gravel in Manila at 1.80 pesos and sand at 1.20 pesos per cubic meter. Filling-in material was obtained by the city of Manila for 41 centavos per cubic meter placed on the bank of Pasig River below the mouth of Mariquina River. Pasig River sand has been delivered in Manila for 1 peso per cubic meter.

Stone.—Comparatively little stone is used in the Philippines. A certain variety of volcanic tuff is employed in native construction, and crushed stone is used as road metal and in concrete mixtures. Gravel is used more widely than crushed stone, however, because of its cheapness. Road metal for the city of Manila costs 1.23 pesos per cubic meter exclusive of transportation, according to the figures of the city engineer.

In the past Cebu Province has used the soft porous coral which covers all accessible parts of the province for most construction work requiring crushed or rough stone. Recently a quarry has been opened near Danao, which yields a superior grade of rock. A condition believed to be unusual in the coral formation is revealed in the excavation at this quarry site. Although the coral is of Pliocene or perhaps even of more recent age, it has been impregnated by waters carrying silica, which has replaced the larger portion of the original calcium carbonate. The silicified rock is not only hard and, therefore, more resistant to wear than the original coral, but since the rock still contains an appreciable quantity of calcium carbonate, which is an efficient binding agent, it should develop superior cementing qualities. The quarry is situated on transportation lines, and the rock has come into general use over the province. The district engineer at Cebu, who is responsible for the location and development of this quarry, reports that 11,790 cubic meters of crushed rock were taken out during 1913 at a unit cost of 1.80 pesos, exclusive of transportation.

Marble from Romblon Island is now being used by the Romblon Marble Company, which was organized in the latter part of 1913 for the manufacture of monuments. The Bureau of Science has on exhibition a baptismal font made by this firm which contains one block of marble about 1.2 meters in diameter. The alleged difficulty of obtaining blocks of suitable size free from joints has deterred earlier exploitation of the Romblon stone. About 2,000 pesos' worth of marble chips are shipped from Romblon to Manila each year for use in ornamental cement construction.

Portland cement.—The Rizal Portland Cement Company has begun the construction of a plant at Matiquio, a barrio of Binangonan, Rizal Province. This company controls a large area of Binangonan limestone at San Guillermo, about 7 kilometers north of the plant site. The limestone will be mixed with volcanic tuff which will be quarried at an adjacent site, both materials being transported to the plant by aërial cable. A single rotary kiln 34 meters long and 2 meters in diameter is being installed with provision for the subsequent installation of a second similar kiln. Following established practice in the Orient, this company has purchased European machinery and will erect a mill of European design.

The local conditions governing manufacture at Binangonan were discussed in The Mineral Resources for 1911. Fuel will be transported from Manila to the mill via Pasig River and Laguna de Bay. The product will be shipped to Manila as a distributing center over the same route. The distance between the proposed site and Manila is about 30 kilometers. The plant will undoubtedly manufacture lime as well as cement.

Importation of Portland cement during the calendar year of 1913 amounted to 425,000 barrels, according to the records of the Collector of Customs. The invoice value of this quantity of cement was 1,623,692 pesos, or 3.80 pesos per barrel. Import duty (60 centavos per barrel), wharfage, and other charges increase the cost so as to make the selling price in Manila 4.40 pesos or more per barrel. Nearly 50 per cent of the cement imported into the Philippines in 1913 came from Germany. Hongkong supplied 27 per cent; East India, 11 per cent; and Japan and China, each about 6 per cent of the total consumption. The United States furnished the Philippine Islands just 8 barrels of cement in 1913. The rapidly declining importation of cement from the United States, even with the advantage of free entry, began several years ago and was discussed in The Mineral Resources for 1912.

Salt, mineral waters, and miscellaneous nonmetals.—Salt manufacture in the Philippines is fully described in former issues of The Mineral Resources. Mineral water is bottled at Los Baños, Laguna, and in a small way at several other places in Luzon. The production of both salt and mineral waters is estimated with the normal increase for 1913.

The Manila Gas Corporation imports from Europe, at excessive unit cost, ocher or a related hydrous oxide of iron which is used in coal-gas manufacture for the removal of sulphur. Material identical with the imported commodity in general appearance is found in abundance in the Angat iron region, Bulacan Province.

A small production of lithographic stone, obtained near Angat, Bulacan, and used locally, is reported for 1913.

A Japanese glass factory in Manila used insignificant quantities of quartz and feldspar during the past year. Part of the supply of these materials is obtained locally, but the greater part is imported from Japan.

GOLD DREDGING IN THE PHILIPPINES

By WILLIAM KANE

(*Superintendent of the Gumaus Placer Company*)

Placer mining has become one of the most important of Philippine industries. The recognition of the value of the alluvial deposits of gold in the Islands came only after a long period of experimentation and the usual tale of hardship and struggle. The growth of the industry during the last three years has been very rapid. During that time, two old dredges which before had failed to pay have been put into successful operation; three new dredges have been completed; two are nearing completion; and three others are soon to be constructed, with promise of even more in the near future.

Gold-bearing alluvium has been found in Cagayan, Ilocos Sur, Mountain, Pangasinan, Nueva Ecija, Bulacan, Rizal, Tayabas, Ambos Camarines, Catanduanes, Mindoro, Masbate, Panay, Surigao, Butuan, Misamis, Bukidnon, and Zamboanga. Of these districts, only Ambos Camarines is at present producing gold on a large scale, but three others, Tayabas, Rizal, and Surigao, are now installing machinery and will be operating in the near future.

There are at present six dredges being operated in Ambos Camarines: One by the Gumaus Company; two by the Philippine Dredges, Limited; one by the Maximelo Gold Dredging Company; one by the Malaguit Gold Dredging Company; and one by the Philippine Dredging Syndicate. The Philippine Dredges, Limited is constructing three other dredges, one wooden-hull dredge with 8.5-foot close-connected buckets, one with 6-foot close-connected buckets, and an all-steel dredge with 9-foot close-connected buckets which is being built in Australia. In 1913 four dredges operated during the entire year, and one operated for about six months. The gold produced from these dredges during 1913 amounted to 643,776 pesos.[1]

In the Philippines at the present time probably more different types of dredges are represented than in any other district

[1] One peso Philippine currency equals 100 centavos equals 50 cents United States currency.

in the world. There are in operation or in process of building, locally, one or more dredges of the following types:

1. Loose-connected or link-bucket type; revolving screen and one bank of tables on each side; controlled by headlines and side lines; no stacking ladder used.
2. Loose-connected or link-bucket type without screens or side tables, but with two long sluices one above the other, fitted with several different types of riffles; controlled by headlines and side lines; no stacking ladder.
3. Close-connected buckets, with revolving screen, two banks of tables on each side, and stacking ladder; controlled by spuds and side lines.
4. Close-connected buckets, without screens, with long central sluice and undercurrents on each side, no stacking ladder; controlled by headlines and side lines.
5. Close-connected buckets, with revolving screens, and single bank of tables on each side; no stacking ladder; controlled by spuds and side lines.
6. Loose-connected buckets with screen and shaking tables, also after table and save-all; no stacking ladder; controlled by headlines and side lines. Hull of steel.

Placer ground.—The placer areas in the Philippine Islands are small as compared with other famous fields, but are sufficiently large to present very profitable work. It is interesting to note that except for a few feet of surface all the ground dredged in the Philippines has been below sea level and that the tide flows nearly to the head of the rivers on which the dredges are located.

The gold in general is much more angular than gold found in placers in other countries. It is usually very fine and occurs as small well-shaped crystals. Only a small quantity of rounded gold has been found. The only exceptions found so far are at Cansuran, Surigao, and at Umerai, Tayabas. An unusual feature is found in Paracale and Malaguit Rivers in the fragments of gold-bearing quartz picked up by the dredge. These vary from pieces the size of a pea to bowlders weighing one hundred kilograms. Gold is found in these bowlders filling pockets or vugs. It is fine and crystalline, forming a spongelike mass.

The gold in the Paracale district is usually found in the layer of gravel next to the bedrock and also filling the crevices and cracks of the bedrock. The gold-bearing gravel varies from 0.3 to 3 meters (1 to 10 feet) in thickness. Very little or no gold is found in the sands and clays which overlie.

At Gumaus little or no black sand or pyrite is found. At Paracale and Malaguit, however, large amounts of magnetite, ilmenite, pyrite, and some metallic copper, with other accompanying heavy minerals, are found in places. In Nueva Ecija the gold is even finer than at Paracale, and exceedingly large amounts of black sand are found, which make the saving of gold very difficult.

On Paracale and Malaguit Rivers there are mangrove roots and soil for about 2.4 meters (8 feet) in depth. Below this is a layer from 3 to 6 meters (10 to 20 feet) of black sticky clay or "pug," under this is a thin layer of sand, and below that is the pay gravel which is from 0.3 to 1.5 meters (1 to 5 feet) thick. The bedrock is a decomposed granite or gneiss, and is well adapted for dredging.

At Gumaus there is about 1 meter (3 feet) of soil, then 3 meters (10 feet) of yellow clay and from 6 to 9 meters (20 to 30 feet) of black clay or "pug," below which is the layer of pay gravel which varies from 0.3 to 4.5 meters (1 to 15 feet) in thickness. There is very little quartz in this gravel, and none of the quartz is gold bearing, such as is found in Paracale. The ground, so far worked, varies from 30 to 90 centavos per yard recovered. Some patches have been dredged that yielded as high as 2 pesos per yard. The greatest depth dredged is 15 meters (51 feet), while the average depth is about 11 meters (35 feet).

The gold is very unevenly distributed throughout the Paracale district, and for this reason, unless drive pipes are put down every hundred feet, even an approximate value cannot be obtained. Where the gold-bearing gravels are thick, the values shown by drive pipe seem to check fairly well with the dredge output, but where the gravel bed is thin the results cannot be depended upon. Besides this, the gold is found in irregular streaks on the bedrock and a drive pipe cannot be relied upon in such ground. Nevertheless, it is important that all placer properties be thoroughly tested in order to obtain even an approximate idea of the value of the ground. In order to do this it is essential that a good machine, making a bore no smaller than 9 centimeters (3.5 inches), be used and that a man be in charge who thoroughly understands the proper use of the machine.

The difference between Philippine placer ground and that in other countries, as shown so far in working with dredges, is the extremely large percentage of fine material and clay in the former. In California only from 30 to 40 per cent of the material dredged passes through the screens, and it is generally composed of clean sand with very little clay. In this country the alluvium has undergone weathering and decomposition, due to the extreme oxidizing power of the elements in the tropics, and the result is the production of clay and soil so that from 70 to 80 per cent of the material dredged passes through the screens. It also has the disadvantage of being made up largely of clay which is sticky and very hard to disintegrate, resulting in loss of gold. Even the gravel bed in which the gold is found has undergone considerable decomposition and has produced clay.

Philippine dredging practice.—The character of Philippine placers presents an element in dredging that requires special attention and methods of treatment somewhat different from the usual practices. It appears from tests made on the tailings and samples taken from the buckets that the present dredging practice only recovers from 60 to 85 per cent of the gold in the ground. Because of the unreliability of drive-pipe tests in these deposits, samples taken in this manner are the only means of testing the efficiency of the dredge. Dredging men are beginning to realize this, and are gradually changing the design of the dredge to suit conditions. The principal changes which would seem to be advantageous are increased screen area and increased water pressure at the nozzles which play upon the screens. With suitable screens and water pressure, it is my belief that ground averaging 25 centavos per yard can be profitably worked with dredges up to 7-feet capacity. With larger dredges and cheaper power, costs could probably be reduced still further. However, the adaptability of very large dredges to ground of this character is questionable.

The pontoons.—The first principle in dredge building is to have a hull of sufficient strength to support rigidly the great weight of machinery and to withstand the excessive strain to which it is subjected when the dredge is digging, particularly the shock caused by the changing pitch of the bucket line. If any weakness develops, the machinery is apt to be thrown out of alignment, and excessive wear or breakage results.

Steel hulls have not yet been tested in the Philippines. Steel has been proved to be superior to wooden hulls when working in fresh water, but when working in salt water, as is the case in the Paracale district, its superiority is questionable. Furthermore, the tendency toward rapid oxidation in the tropics may be a serious handicap to a steel hull. Philippine pontoons have been made of native wood and also of Oregon pine. It appears from evidence so far obtained that Oregon pine is on the whole more satisfactory. However, the Philippine wood used was not representative of the best Philippine wood, and therefore should not be taken as an example.

It is essential that all construction of Oregon pine should be well reënforced with steel plates, and in all cases the hull should be well ventilated. The pontoon should also be sheathed with tarred felt covered by 1.5-inch boarding to protect the hull from teredos and fresh-water borers. This, I believe, is a precaution peculiar to the tropics where such water animals are found.

Ladder and buckets.—In order to handle the clay encountered in the deposit and to secure a proper capacity, it is necessary to have a specially designed bucket. Ordinary buckets designed for handling gravel are almost useless. For the best design the body of the bucket should be short and the lip cut well back to insure quick and clean dumping. In the Philippines as elsewhere, the close-connected buckets have many advantages over the open connected. It is an advantage to have the machinery so designed that the buckets can be driven fast while digging the overburden and more slowly while digging pay gravel and bedrock. A larger quantity of clay can be handled by moving laterally more rapidly and by decreasing the distance through which the digging ladder is lowered on each swing.

The wear on buckets and on the digging end generally is very light in the Paracale district because of the soft material handled.

Spuds and headlines.—Dredges are operating in the district with spuds and also with headlines. There are advantages claimed for each system. If the operator desires to strip the overburden for about 3 meters (10 or 12 feet) ahead of the working face and then drop back to clean up the gold-bearing gravel, the headline is preferable, but the modern practice in the United States is to use spuds, holding the dredge right to the face and working to bedrock with each step. It is also claimed that the use of spuds saves time by eliminating the handling of heavy headlines, which is especially difficult in a wooded country.

Screens.—The modern screen is a revolving cylindrical screen, constructed with a framework of heavy channel irons, to which perforated plates are bolted. This makes it possible easily to replace the perforated plates which have to be renewed about once every nine months. The plates are about three-eighths of an inch thick, and the perforations vary from one-fourth of an inch at the upper end to one-half of an inch at the lower end.

The dredges on Paracale River are operating without screens. The material is dumped into a large sluice, and water is supplied through nozzles at the head and also at several points along the sluice to assist in breaking up the material. For about 9 meters (30 feet) from the head the material passes over stationary perforated plates. The undercurrent from the perforated plates passes out over wide tables which are fitted with riffles and placed on each side parallel to the box. After passing over the tables, the material is returned to the main sluice. The overflow passes straight down the main box, which below the plates is fitted with heavy angle-iron riffles. There is also a clay sluice through which the valueless overburden can be passed, thereby relieving the tables and sluice from performing unprofitable work. This system is similar to that used in hydraulic mining in all parts of the world and is still used in dredging in New Zealand and Australia, but is not used in dredging in the United States; in Alaska it is called flume dredging. It appears that this practice would be good where there is not an excessive amount of clay and where there are not many large bowlders, which have to be removed by hand from the sluice box.

The revolving screen with high-pressure nozzles would seem to be best adapted for material with a large percentage of clay and also wherever a stacking ladder is necessary.

Tables.—On account of the fineness of the gold and the large percentage of fine material in the wash, the table area should be somewhat larger than usual. About 80 per cent of the gold is caught in the first few feet of the first four tables where mercury is used in the riffles. The advantage of using mercury is very marked and is now considered the best practice. The use of matting and expanded metal is decreasing, and is being replaced by riffles and mercury.

Clean up.—The general practice is to clean up the main tables at least once a week and the side sluices once a month. In cleaning up, the riffles are lifted and the entire material left on the tables is collected and washed in a streaming-down box. This practice is adopted on account of the unreliability of the laborers. The tables on dredges using screens and a distributing box can be cleaned up in sections while the dredge is in operation. The sluice box type without screens necessitates a shutdown before the main sluice can be cleaned up.

Pumps.—It is advantageous to have the pumps driven by a separate engine and not from the bucket engine. There should be at least two pumps—one high pressure and one low pressure—rather than one low-pressure pump of large capacity, especially where much clay is encountered.

Power.—Power is becoming a serious problem in the Paracale district. The available wood supply is being rapidly exhausted, coal is very expensive, and oil fuel is now receiving serious consideration. It appears that Diesel engines would furnish by far the cheapest power. A central electric power plant run by Diesel engines would be an excellent solution of the problem.

Dredge operation.—About the best work that a dredge has done so far has been to operate throughout 75 per cent of the working days. Most material made of iron and steel has a life about two-thirds as long as in the temperate zone. This is particularly noticeable in wire cables exposed to salt water.

The distance from the base of supply makes it necessary to keep in stock a large supply of extra parts. Any unlooked for breakage is very expensive for this reason, and may cause a delay of from one to three months.

The following is a representative force of men required for a dredge:

		Pesos.
Dredge force per shift:		
1 white winchman	per month	250.00
1 Filipino winchman	per day	1.25
1 Filipino fireman	do	1.25
1 Filipino greaser	do	1.25
9 Filipino laborers	do	1.00
Additional day force:		
1 white mechanic	per month	300.00
1 Japanese blacksmith	per day	3.35
1 Filipino blacksmith helper	do	1.00
2 Filipino assistant machinists	do	1.50
1 Filipino capataz	do	2.00
5 Filipino laborers	do	1.00

The cost of operation per yard, representative of the best practice, is as follows:

	Pesos.
Labor, white	0.03
Labor, Filipino	.027
Superintendence	.010
Fuel	.044
Supplies	.005
Repairs	.015
Total	0.131

MINE EXPLOITATION AND THE CAUSES OF SOME MINE FAILURES IN THE PHILIPPINES

By F. T. Eddingfield

The question, "Why have there been mine failures in the Philippines," undoubtedly has been asked in many parts of the world and, particularly, in the Orient. While apparently good reasons might be given for almost every specific failure, there is practically no case on record where it was not reasonably possible either to have forestalled or to have averted failure. There are many things that must be done correctly to insure success in mining, and failure to do all of them is often very expensive, if not disastrous.

Too many people believe that mining is a gambling game, wherein wealth is to be won with a small expenditure of capital. They assume, too, that if a mining property has a few tunnels and shafts and if a mill has been erected success is assured; or, if there is no mill, that the installation of a mill is all that is necessary to attain success and great wealth. Legitimate mining is no more a gamble than any other recognized form of business. Mining has reached the stage where it is business. Since mining is a business it should be undertaken in a businesslike manner. Any procedure based on the assumption that it is a gamble is totally unjustified and, it may be added, is usually fatal.

When the purchase or operation of a mine or mining property is contemplated, it is necessary first to obtain all the information possible about the property as it stands at that time. Next should be determined what additional information is necessary before the erection of a mill is justified, how this information is to be obtained, and how much it will cost. The money spent in obtaining this additional necessary information is the only risk that should enter into a mining enterprise. It is far better to risk a small sum in this kind of investigation than to gamble with a large sum and take the chance of losing not only the large sum but the small sum as well, for in any case the specified information must be obtained sooner or later if the mine is to be operated.

Most enterprises are financed by promoters who control the property. The promoter presents his proposition to men with capital or he himself forms a stock company and sells stock to obtain funds to operate the mine. It should be remembered that a promoter is always an interested party. Therefore, his statements are almost certain to be biased, even though unintentionally, and they should never be taken as fact without confirmation. In all cases the property should be examined by a disinterested engineer who is capable of judging the economic possibilities of a prospect and the true value of a mine. The statements so far made apply both to quartz and placer mining. The special points to be determined in each case differ somewhat and will be discussed separately.

QUARTZ MINING

Sampling is the foundation upon which all mine valuation is based. Its importance cannot be overestimated. It is, therefore, imperative that sampling be done by some one who can be absolutely impartial and whose training and experience enable him to know where and how to take samples in order to show the true value of the ore body and to interpret the results correctly. Even this is not enough. He must also know how to protect his samples from being "salted," either accidentally or intentionally. Many an engineer has based his report on samples which, without his knowledge, had been salted and has caused the loss of a large sum of money in consequence.

There are properties in the Philippines on which thousands of pesos were spent before a representative sample was taken. In one case, large-sized drifts, several hundred meters long, were driven on four levels, representing an expenditure of probably 40,000 pesos,[1] or more. The owner had accepted the samples of the mine manager as representative, under the imperssion that the ore was of good value. Later the mine was sampled by an unbiased engineer and was found to be practically valueless. If the independent examination had been made earlier, at least 35,000 pesos could have been saved. The prospector, in nine cases out of ten, fails to take a true sample; his desire to find good ore influences his sampling and causes him to favor, unconsciously perhaps, the places where he knows good ore can be found. Several local properties have been sampled by a Government engineer and were found to be only about one-tenth as valuable as the prospector's samples had indicated.

[1] One peso Philippine currency equals 100 centavos equals 50 cents United States currency.

If the sampling report shows that the ore contains workable value, it is next necessary to determine if this value can be extracted economically. There are many ores which carry apparently workable values but are so refractory that the cost of extraction is prohibitive. Practically all oxidized gold ore is easily and cheaply treated, but ore rich with sulphides or tellurides requires a more complicated and expensive method. It is, therefore, necessary to obtain, for testing, samples of the primary ore below the zone of oxidation, unless there is sufficient oxidized ore alone developed to insure profitable returns on the investment. As will be brought out later, ore tests are also essential in determining the type of mills to be installed.

After having determined that the property contains ore from which the values can be economically extracted, the next step is to find out how much ore of this character is present. This is the most important step of all, and neglect accurately to determine the size of the ore supply has caused the failure of more mines than any other one element. In this matter common sense and business experience should protect the investor. No business man pays out hundreds of thousands of dollars for a commodity without knowing exactly what quantity of the commodity he is to receive, no matter how attractive the sample submitted may be. Yet this is what the mining investor does who fails to ascertain the available tonnage in his ore reserves.

Mining experience has developed various methods of eliminating, to a great degree, any uncertainty as to the quantity of ore available. The value of these methods has been proved many times. It is generally considered good practice to divide ore into three classes; namely, proved ore, probable ore, and prospective ore.

Proved ore is that which has been blocked out on four sides by drifts, raises, and shafts, so that a sample can be taken, for at least the whole width of the vein or working, at any place on the periphery of the block thus formed; furthermore, any one side of the block should not exceed 30 meters (100 feet) in length and, where the values are irregular, the block should be much smaller. Any strip of ore next to a drift or winze, for a distance of 4.5 meters (15 feet) perpendicular to the working throughout the entire length of the working and equal in thickness to the width of the working, is also considered as proved; in some cases, a depth of 7.5 meters (25 feet) perpendicular to the length of the working is allowed.

Probable ore is a block of ore three sides of which are exposed by drifts, winzes, etc., provided that the parallel sides are not more than 30 meters (100 feet) apart. Ore between parallel drifts not over 30 meters (100 feet) apart on the same vein and that portion of the vein next to the proved ore and exposed only by crosscuts are probable ore.

Prospective ore is ore exposed on one or two sides only, or at various points along the vein. All territory not included in the first two classes, where one might reasonably expect ore to be present, is accepted as prospective ore.

The estimated value of a mine is commonly based on the net value of 90 per cent of the proved ore plus 45 per cent of the probable ore. The value of this estimated quantity must be sufficient to yield a profit that will refund the original investment with at least 10 per cent per year on the investment in addition. The remainder of the probable ore and all the prospective ore then remain as a possible extra profit, but their possible value is not to be considered in the valuation of the property.

Before the exploitation of a property is seriously considered, sufficient proved ore and probable ore should have been developed to meet the above specification. To enumerate the cases in the Philippines where this stipulation has been neglected would serve no good purpose now. To my personal knowledge, of 19 properties on which mills had been erected, no more than 3 fulfilled this requirement, and 7 mines have failed for no other reason than lack of profitable ore. In several other cases lack of ore, combined with other mistakes, caused the failure of the property.

Even though sufficient ore is developed, its value assured, and a successful extraction process devised, there are other elements which may prevent profitable working of the mine or mill and which require careful consideration; these are power, transportation, climate, unavoidable delays, cost of supplies, labor, and special problems in connection with geologic conditions.

Power is frequently the most troublesome and expensive item in mill operation. Water power is most desirable because of its cheapness. In this country, however, although sufficient "head" can be usually obtained, the supply of water is generally limited and exceedingly variable, and sites for storage reservoirs of even moderate capacity are rare. Miscalculation of minimum water supply is disastrous, and has led to extra expense and delay.

If water power is not available, or is available for only part of the installation, other power must be obtained—from steam or internal-combustion engines or from electricity. The relative merits of these types of power generators is a question for expert advice, since every district has its individual power problem.

To my knowledge the power problem of two mines in the Philippines has been misjudged. At one mine in a district where there was scarcely more than enough wood for timbering purposes a wood-burning boiler was installed. At another mine a water wheel was installed, but the water supply was insufficient for the necessary power. Auxiliary internal-combustion engines were then added; however, at a loss of time and money.

The first consideration in connection with the transportation problem in the Philippines is, of course, the additional time required after the orders are placed before machinery and supplies can be landed in Manila or in the nearest port. This item adds from two months to ten weeks to the time required for the same installation in the United States.

The transportation charges from Manila to the mine, in the case of the Benguet district, are exceedingly high, ranging from 60 to 70 pesos per ton, or per cubic meter. A similar transportation cost would apply to the Mancayan-Suyoc copper-gold district, even if a road existed from the coast. The other principal districts are located near ports so that water transportation is available. Underestimation of the cost of, and of the time required for, transportation has in several cases embarrassed mine operators in the Philippines.

The high cost of transportation is not the only difficulty. It is a problem to obtain transportation for heavy pieces at any cost. It should be remembered also that transportation is an item of operation as well as one of installation and should be included in the estimate for cost of production.

Under the subject of climatic conditions should be considered health, efficiency of labor, depreciation of materials of equipment and construction, floods, typhoons, and landslides.

It is generally recognized that a Caucasian cannot perform as much efficient work in the tropics as he can in the temperate zone. This is due to the high average temperature and the great humidity. After about three years in the tropics a change to a colder climate is considered necessary for the average man in order to regain his health and vitality. This necessitates frequent changes in the staff and the consequent transportation charges to and from the United States. Besides the general debilitating effect of climate, there are tropical diseases to be guarded against. Conditions at present are much better than they were a few years ago, but malaria, dengue, and other fevers; dysentery; and various organic troubles are not infrequent and tend to lower efficiency.

Common labor is, on the whole, as cheap and plentiful as in most mining districts of the world. It is a little difficult to obtain labor at the start in a new district, but once in operation mines seldom lack labor. The Filipino laborer requires more careful supervision than laborers of some other nationalities, but when handled in a proper manner he is cheerful, willing, and sufficiently regular in his work. His wages are low, being from 1 to 2 pesos per day, and the cost of labor per ton of ore, while high in some districts, compares fairly well with similar costs in other countries where hand drilling is the rule. No mines have failed here because of labor troubles.

A great deal of attention must be paid to preservation of materials, and allowance must be made for the rusting of iron or steel, which not only adds to the expense, but necessitates having in stock at the mine more extra parts and extra supplies than would be required in a drier climate. This increases the cost of the mill and makes necessary a larger allowance for depreciation, or an allowance for more rapid depreciation. The depreciation of wood is an important item, although the white ant, which is so destructive to houses, does not attack either mine or mill timbers. It is believed that it does not attack the mill timbers because of the constant jar of the machinery. In the mine, timbers are destroyed by wet rotting, by dry rotting, and by boring insects. Timbers in a damp working place or drift, where there is not a good circulation of air, are quickly covered by fungus and decay rapidly. This condition is avoided by maintaining a good air circulation. Whenever native woods other than certain grades of first- and second-group timber are continually wet, they rot rapidly. Dry rotting is also common; it occurs where wood, particularly Benguet pine, is exposed to the elements for any length of time and also in mine timbers. This dry rotting may either work from the outside toward the center or from the center outward. Borers are frequently seen working in mine timbers. They are not a serious problem, but make necessary the renewal of timbers occasionally.

The mining men, as well as the road- and bridge-building department of the Government, have learned from bitter experience the damaging power of the elements in the Philippines. It is not enough for the engineer in either profession to base calculations on the highest previous water level nor on the records for typhoons in any one district; nor is it enough to be satisfied with apparently solid rock as a foundation. One can hardly appreciate the destructive power of a rainfall amounting to a meter (36 inches) in twenty-four hours, such as took place in Baguio a few years ago, especially when such extreme precipitation occurs in an exceedingly rough country with deep narrow valleys. Records of high water have been broken time and again in various parts of the Islands, and each new record bears a tale of destruction.

The Benguet Consolidated mill at Baguio, Benguet, has been damaged three times by floods; the first flood washed away the entire cyanide plant, and later storms have washed away everything including the stamps. The Bua mill also suffered damage sufficiently to cause it to suspend operations. A flood in northern Tayabas washed out the sluice boxes and pipe line of the Luzon Gold Company, causing the loss of a large part of the gold held in the sluice boxes. Floods have also destroyed roads, bridges, and railroads, delaying transportation for months at a time.

Typhoons lend an element of risk, but they are less difficult to safeguard. Only comparatively small damage has been done to mining property by typhoons. A dredge in Masbate was wrecked by a typhoon, and the partly erected headframe of the San Mauricio mine at Mambulao, Ambos Camarines, was blown down.

In Benguet still another source of risk demands attention; that is, landslide. The relief is exceedingly great, and the country is made up of many kinds of rocks intersected by numerous veins and joints. The heavy precipitation of the rainy season, aided by the excessive oxidizing power of a tropical climate, has loosened great mases of rock and set whole hillsides in motion. Slides occur everywhere, and occasionally dam up a stream, thus impounding a body of water which eventually breaks through and often destroys everything in its path. A small valley back of the Benguet Consolidated mine was dammed up in this manner, and when the water broke through it carried away the plates of the mill, which had been removed to a supposedly safe place, as well as the storehouse and several dwellings, causing some loss of life.

While investigating other conditions, it is necessary to obtain data relative to the possible location of a mill. The first consideration is that of safety. The mill should be located where there is the least possibility of flood or landslide. The mill should be so located that the cost of transportation of ore from the mine will be small, even though the initial cost of installing the mill at such a site is greater than it would be at some other possible location. The expense of ore transportation is much more important than machinery transportation. If water power is available, however, it should be considered the second most important item and should take precedent over ore transportation if other conditions are equal.

No fixed rules can be given, but each item of mill costs should be compared with every other item and the most economical balance obtained in the mill site should be chosen. Some of the principal cost items are:

Ore transportation.
Power:
- Water power.
- Fuel for steam power.
- Fuel for internal-combustion engines.

Water supply.
Handling ore pulp.
Handling mill solutions.
Disposal of tailings.
Transportation of supplies.
Transportation of the product.

A hillside slope is desirable as a mill site, but is not as important in all-sliming cyanide mills as in concentration mills. The movement of ore pulp through the mill by gravity is economical up to a certain point, but it should be remembered that a large part of the pumping in a cyanide mill can be charged to agitation and washing and that the solution which itself makes up a large portion of the pulp or slime must be pumped back to the head of the mill whether it be done in stages or in one lift. Consequently, it is not always best to sacrifice compactness in order to have the pulp flow by gravity. The principal steps in which gravity may be utilized economically are:

Mine to ore bin.
Bin to intermediate crusher.
Intermediate crusher to pulverizers.
Pulverizers to extraction tanks.
Extraction tanks to filter.
Filter to waste dump.

Any additional steps by gravity are of little advantage and tend to make the total height of the mill too great for economical working.

After having satisfactorily disposed of all the foregoing points, that is, having found the ore to be of a sufficiently valuable grade to be adapted to commercial extraction processes and to be present in the quantity already specified as the minimum to be accepted and having solved the power problem, the transportation problem, and all the problems connected with sanitation, labor, depreciation of plant, floods, typhoons, and landslides, the next problem is the purchase and erection of the mill. But previous to this stage of the investigation no step should be taken toward the purchase of a mill.

Many instances can be cited wherein mills in the Philippines have been hampered because their erection was not preceded by the preliminary investigations which have been prescribed. In three mills the process used failed to make a satisfactory recovery of values. Two other mills had machines that could not be used; in one case because they were unsuitable, or unnecessary, for the ore treatment, and in the other case because they were too complicated to be operated by unskilled labor. In several cases, cheap machines in poorly arranged mills have cost, in repairs and alterations alone, more than enough to have offset the extra cost of good machines, without taking into account the loss entailed by delays and inefficient work.

The ore tests already made to determine whether or not the ore can be treated at all will show what process is best adapted for extraction of values. Many good mines have failed because their mills were not properly designed for the best extraction. One process may recover 98 per cent of the value of the ore, while another, eminently suited for a different class of ore perhaps, fails to extract more than 30 per cent. Amalgamation alone seldom recovers more than 30 per cent of the gold from Philippine ores. Several mills have tried this method, but the ores are usually not rich enough to pay when two-thirds of the value is lost. Amalgamation and concentration have been used in some cases, but this system usually recovers only about 70 per cent of the values, and the extraction of the values in the resulting concentrates requires additional treatment. In the Philippines the ores usually carry so large a percentage of sulphides that the cost of recovering the gold from them is high. Fine grinding and cyanidation have proved successful locally wherever tried so far. However, a sample of ore was examined in the Bureau of Science a few years ago which could not be successfully treated in this manner, but required very fine grinding and a modification of the ordinary cyanide process involving the use of bromocyanide; yet this ore assayed 40 pesos per ton.

Before the mill at the Colorado mine in Masbate was built, no mills existed in the Philippines which made the most economical recovery of values. Two mines failed absolutely because the mill was not of the proper type for extracting the gold. Several others managed to pay expenses, but recovered only from 40 to 60 per cent of the gold in the ores.

The extraction process once decided upon, the machines for accomplishing the extraction can best be determined by an experienced mill man, who should familiarize himself with the ore before ordering machinery. A machine which does wonderful work with one kind of ore may be a complete failure with another. At this distance from the source of supply, machines should be ordered which require the minimum repair. Economy demands the best wearing machinery, since breakage means long delays, unless a large supply of extra parts is at hand. The machines which are the simplest in construction and have the fewest moving parts are usually the strongest and best wearing. Machines of this type are easy to operate, and are therefore less apt to be injured by the unskilled and ignorant workmen to whom their care is frequently, of necessity, intrusted.

Finally, even if everything else has been properly carried out, the success of the property depends upon the manager. The extra expenditure required to get a good experienced engineer for the position may be saved fifteen or twenty times over in mining and milling. There are several instances in the Philippines where a poor manager has caused the loss of many thousands of pesos.

In general the same kind of precautions must be observed in placer mining as in quartz mining. However, there are a few points that require special attention.

The testing of placer ground is accomplished by boring or by sinking pits or shafts. The number and arrangement of holes depends upon the shape and size of the alluvial deposit and also upon its uniformity. Holes should be put down at regular intervals. If the alluvium is found to be irregular in character and depth and also in values, the interval between holes should be small. This is especially true where "high values" are occasionally found, for often "poor values" will be found near by to offset them. Uniform alluvium with more or less uniform values requires fewer holes to determine its average tenor. These points are frequently overlooked, and in some cases the oversight has proved very costly. Several years ago an engineer put down nine holes to test a certain tract of placer ground. One hole showed almost 21 pesos per cubic meter (16 pesos per cubic yard); the other eight holes each showed only 1.30 pesos per cubic meter (1 peso per cubic yard). The engineer averaged the nine holes, and by doing so obtained a value almost three times as large as it would have been had the one high value been lacking. The error of such a method is apparent.

Considerable skill is required to put down a drive pipe and recover the material making up the core. The difficulty is to obtain no more and no less material than should rightfully belong within the circumference of the pipe. In sinking a pipe through bowlders, insufficient material is recovered, while in sinking through a layer of sand or fine gravel too much material is often taken out. In all cases, the material taken out should be measured and checked up with the advance of the pipe every few feet and allowance should be made for the excess or deficiency. At the same time careful record should be kept of the character of the various layers of clay, sand, and gravel passed through and of their thickness, depth, and respective gold content. These refinements require very little extra work, but are invaluable subsequently to the dredgeman.

In obtaining the value of the gold per cubic yard, mistakes can easily be made—

1. By taking out too much or too little material from various strata, as mentioned above.
2. By underestimating or overestimating the total material taken out.

   These two sources of error can only be checked by measuring the material taken out for every 2- or 3-foot advance of the pipe.
3. By loss of gold in panning the material recovered.
4. By failure to ascertain the fineness of the gold recovered. The gold found in placer deposits in the Philippines varies in fineness from 650 to 850 parts per 1000.

There are two cases in the Philippines where placer deposits were tested and reported to be of value and later were found to be valueless. In one case, a dredge was purchased and installed, failing almost immediately because there was not sufficient gold value recovered. Another property was reported to be very rich, and remarkable samples were submitted by the claim owners as proof. A company was formed and stock was placed on the market, but fortunately the error in valuation was discovered before much money had been spent. Placer samples are very easy to "salt," and it is almost impossible to detect salting in them. It appears that the samples in the two cases cited above had been salted.

Precautions similar to those mentioned under milling must be observed in regard to the character of the dredge, power, machinery, transportation, depreciation, supplies, and other data. One of the most important items in dredge design is the character of the pontoon. The pontoon undergoes excessive strains in practically every direction. Strong and properly placed bracing is, therefore, essential. Below the water line the pontoon should be proof against the teredo. In the Philippines this wormlike mollusk can be guarded against by the use of tarred felt sheathing for the submerged portion of the pontoon.

A PRELIMINARY CHECK LIST OF PHILIPPINE MINERALS

By WARREN D. SMITH, F. T. EDDINGFIELD, and PAUL R. FANNING

The following 113 mineral species and varieties comprise all those known with certainty to us to occur in the Philippines. There are others whose presence we suspect, but which have not been definitely identified. For instance, tin, native brass, and diamonds are said to exist here, but this laboratory has no authoritative knowledge of them.

All the minerals herein mentioned are in the collections of the Bureau of Science, and have been collected for the most part during the American régime. The collections of the old Spanish Mining Bureau were almost worthless when they passed into the hands of the Americans. Whether the best specimens had been transferred elsewhere at the outbreak of hostilities we do not know, but we have reason to suspect such to have been the case.

Three other mineral collections in the city of Manila have been consulted; namely, that of the Ateneo de Manila of the Jesuit Order, that of the Santo Tomás University of the Dominican Order, and lastly that of the Ateneo de Rizal, but we have found only a very few specimens which were not in our own collection. As there is some doubt also about the localities of some of the minerals in those collections, we have purposely omitted several species.

Our acknowledgement of assistance from the curators of these institutes is hereby gratefully made.

It will be noted that many of the minerals in the following list have no economic value, but the fact that a substance has no present commercial value is no reason for excluding it from a catalogue. The future will undoubtedly see a number of minerals now thought to be of little or of no use to man become of great commercial value. For instance, when the large deposits of concentrated iron oxides, like hematite and limonite, become exhausted we shall be forced in all probability to turn to the iron-bearing silicates of too low a grade to be worked economically at the present time. The mineral leucite with its 21 per cent of potash is a valuable prospective source of this important ingredient of the soil, but only until recently has any one thought seriously of extracting it.

We have before us the list of minerals of Taiwan (Formosa) by Okamoto, of the educational bureau of that island. In this list he gives 50 minerals, less than half the number we have in the following list. Six of these we have not yet found in the Philippines, while there are 3 others which we suspected to be here but have not certainly determined.

We take this opportunity to urge all the mining men and students of the various schools and colleges to send specimens of any minerals which they may think new or interesting to the Bureau of Science. It is reasonable to expect that when more persons shall become interested in this line and more observant of natural objects this list will be greatly augmented. We are already greatly indebted to many of our friends of the mining community for valuable specimens.

It is to be regretted that up to the present we have not made many studies of a mineralogic nature, as more pressing investigations in the mining fields have prevented us from doing so. The compilation of this preliminary list has suggested several subjects which can be profitably taken up in the future.

CHECK LIST OF PHILIPPINE MINERALS

Actinolite—$Ca(Mg, Fe)_3Si_4O_{12}$.

This mineral occurs as acicular green crystals in the crystalline schists of Ilocos Norte. It is classed as one variety of asbestos in the trade. There is no production in the Philippines.

Agate—SiO_2.

Agate is found in many parts of the Archipelago where silicification has occurred. Occasionally some specimens suitable for polishing are found. There is no production in the Philippines.

Albite. (See Plagioclase).

Altaite—$PbTe$.

This mineral occurs intimately mixed with sylvanite and free gold in specimens from the Tumbaga mine, Ambos Camarines. It is tin white, sometimes with a bronze tarnish, and occurs as negative crystals or pseudomorphs after quartz crystals or fragments. Development work exists only at this mine.

Amethyst—SiO_2.

Some large crystals have been found in Palawan, but this mineral is not common in the Philippine Islands. One large specimen of amethyst crystals from Mount Tumarbon, Palawan, can be seen in the Santo Tomás Museum. When perfect it is used as a gem. There is no production in the Philippine Islands.

Analcite—$NaAl(SiO_3)_2+H_2O$.

This mineral occurs as an alteration product of leucite in some volcanic rocks of limited distribution in Masbate.

Andesine. (See Plagioclase).

Anorthite. (See Plagioclase).

Anthophyllite—$(Mg, Fe)SiO_3$.

This mineral is a variety of amphibole in long dirty white to brownish fibers, and is associated with serpentine and asbestos. It occurs in Ilocos Norte. In some cases it could be used as a substitute for asbestos. There is no production in the Philippines.

Apatite—$Ca_5(Cl, F)(PO_4)_3$.

Apatite occurs as large yellowish crystals in small amounts in metamorphic rocks near Pasuquin, Ilocos Norte, and also in minute crystals in many igneous rocks in the Philippine Islands. It is valuable for fertilizer if found in large enough quantities. There is no production in the Philippines.

Aragonite—$CaCO_3$.

The mineral is found so far in one locality, Talim Island, Laguna, in long clear crystals in vugs in basalt. It has no economic value.

Arsenic—As (metalllic).

This mineral is deposited presumably from hot springs in the form of kidneys (reniform). It is found near Buguias, Mountain Province. There is no local use for arsenic.

Asbestos—$H_4(Mg, Fe)_3Si_2O_9$. (?)

Asbestos is associated with serpentine in Ilocos Norte. No first-grade asbestos has yet been found. It consists practically of longitudinal fibers. One small sample of cross fiber (see chrysotile) is in our collection. There is no production in the Philippines.

Asphaltum—Complex series of hydrocarbons.

One small specimen was brought in from the Eastern Cordillera, Luzon, which is of doubtful authenticity.

Augite—$(Mg, Fe)(Al, Fe)_2SiO_6$.

This mineral is one of the pyroxene group of silicates—common as a rock mineral. Augite has no economic value at present.

Azurite—$Cu_3(OH)_2(CO_3)_2$.

Azurite occurs as minute blue crystals in some copper deposits of Pangasinan, Batangas, and Mindanao.

Baltimorite—$H_4Mg_3Si_2O_9$.

Baltimorite is a white to bluish fibrous mineral associated with serpentine. It is found in Ilocos Norte. It could be used for steam packing and roofing material. There is no production in the Philippines.

Barite—$BaSO_4$.

Barite is reported from Mancayan as a vein mineral by A. J. Eveland.

Basonite—SiO_2.

This mineral is a velvet black variety of flint known as "touch stone" or lydian stone. It could be used for testing the purity of gold. One sample, No. 176, is in the collection of the Ateneo de Manila.

Beryl (emerald)—$Be_3Al_2(SiO_3)_6$.

Small and imperfect specimens are reported from Mindanao, but nothing definite is known regarding the locality.

Biotite—$(H, K)_2(Mg, Fe)_2Al_2Si_3O_{12}$.

Biotite occurs in various igneous rocks in the Philippines in small crystals, principally in Paracale granite. No economic deposits are known here.

Bituminous coal—Complex composition, principally oxygenated hydrocarbons.

Bituminous coal is found in seams from a few centimeters to several meters thick in Cebu and Mindanao. Formerly there was a moderate production in Cebu. There is none in Mindanao. One specimen from Dumanquilas Bay, Mindanao, shows columnar structure.

Bornite—Cu_5FeS_4.

Bornite occurs massive to finely crystalline in quartz veins. It is probably secondary in origin. This mineral is found in several of the copper deposits in the Islands. An excellent sample comes from "Quien Sabe" claim, Suyoc, Mountain Province. There is development work in the Philippines but no production.

Calcite—$CaCO_3$.

Calcite is generally massive without crystalline faces, but some splendidly crystallized samples of "dog tooth" spar have been found. It is frequently associated with primary and secondary manganese minerals, and is also frequently associated with quartz in ore veins, there being a progression from quartz to quartz-calcite, probably the result of lowering of temperature and pressure. Calcite occurs also as a secondary mineral in igneous rocks; also, as stalactites, stalagmites, and travertine. Marble is found in Romblon and crystallized limestone at Montalban. The mineral is used to manufacture quicklime for sugar refining. Marble is used for monuments and building purposes.

Chalcedony—SiO_2+H_2O.

Chalcedony occurs in irregular milky white patches in jaspers and other rocks in various parts of the Islands.

Chalcocite—Cu_2S.

Chalcocite is a massive gray mineral usually secondary in the upper zones. It is found in Misamis, Mindanao, and Mountain Province, Luzon. There is no production in the Philippines.

Chalcopyrite—$CuFeS_2$.

Chalcopyrite is the most universally distributed ore of copper. It is found as small crystals in a large number of quartz veins, and is associated mainly with galena and usually crystallizes after galena. It is found in small quantities in all of the mining districts. No commercial deposits are known in the Philippines.

Chert—SiO_2.

Chert occurs as nodules in various formations in many parts of the Archipelago, also as radiolarian cherts, probably of Jurassic age. It is well developed in Palawan, Panay, Ilocos Norte, and Balabac. Compare with radiolarian "hornfels" of Central Borneo. It has no economic use.

Chlorite—$H_8Mg_5Al_2Si_3O_{18}$.

Chlorite occurs as fine, green fibrous masses as an alteration product in many igneous rocks. It has no economic use.

Chromite—$FeOCr_2O_3$.

Chromite occurs associated with serpentine in heavy granular masses with mottled black and green appearance in Antique Province, Panay. There is some prospecting but no production.

Chrysoprase—SiO_2 (colored by nickel oxide).

Chrysoprase occurs as beautiful leek-green pebbles in a river near Butuan, Mindanao. One specimen, No. 180, is in the collection of the Ateneo de Manila. This mineral could be used as a gem.

Chrysotile—$H_4(Mg, Fe)_3Si_2O_9$.

Chrysotile occurs as white to greenish silky fibers. Some inferior specimens have been found in Ilocos Norte. Short cross fibers of from 2 to 3 centimeters in length have been found. There is no production, but indications are promising.

Cinnabar—HgS.

Minute red crystals of cinnabar were found in a few samples from Batwaan Creek, Benguet, Luzon. Cinnabar remains in the pan with the gold. It is reported from Mount Isarog, Ambos Camarines. This mineral forms under surface conditions, and is connected with volcanic activity. It is not mined in the Philippines.

Copper—Cu (metallic).

Native copper occurs as irregular, partly crystalline masses and as round shot in alluvium; there are 3 type occurrences; (1) Amygdoloids in extrusives, in Masbate; (2) in alluvials of Malaguit River, Ambos Camarines; (3) reported in some quartz veins in Masbate. Native copper was probably used formerly by Igorots to make pots. It is not used at present.

Corundum—Al_2O_3.

Corundum occurs as pebbles in placers in Nueva Ecija, Luzon.

Crocoite—$PbCrO_4$.

Crocoite occurs in characteristic small orange-red monoclinic crystals in Labo, Paracale district, Ambos Camarines, Luzon. It is associated with galena-bearing rocks, and is not abundant.

Cuprite—Cu_2O.

Cuprite occurs as small clear red crystals in the surface ore of a copper deposit in Antique Province, Panay.

Diallage—A nonaluminous pyroxene.

Diallage is a common constituent of gabbros in the Philippines. It has no economic value.

Enargite—Cu_3AsS_4.

Enargite is probably secondary in copper deposits. It occurs massive and in small gray crystals with luzonite in the old Santa Barbara mine at Mancayan, Lepanto, Luzon. It is mined and smelted by Igorots. Formerly there was a considerable production by a Spanish company; at present it is not important.

Epidote—$HCa_2(Al, Fe)_3Si_3O_{13}$.

Epidote is very rare. It occurs as yellowish grains or in more or less amorphous masses in a few igneous rocks. It has no economic value.

Galena—PbS.

Galena is found in veins only. It is lacking in the walls. Galena was formed generally later than pyrite. As a rule, it is crystallized. It is associated with zinc and pyrite in quartz veins, rarely in calcite veins. It frequently carries silver, but rarely gold. It is nearly always primary. Galena is resistant to decomposition. This mineral is found in veins in Suyoc, Mountain Province; in Batangas; Cebu; Marinduque; Paracale; and Surigao. During the Spanish régime galena was mined to a limited extent in Cebu, but is not mined at the present time.

Garnet—Complex silicates with Fe, Mg, Mn, and Ca as interchangeable bases.

The common species, andratite, occurs rarely in the Philippines as minute wine-red granules in a rock from Bulacan, Luzon. It has no economic value.

Gilsonite—Complex hydrocarbon.

Gilsonite is found in the northern part of Leyte Province adjacent to petroleum seeps in Miocene shale and sandstone. There is no production in the Philippines, but the Leyte deposit is being explored.

Gold—Au (metallic).

Gold occurs associated with pyrite and rarely with galena. It usually occurs as metallic gold in quartz and in calcite veins as wires, plates, grains, and crystals; abundantly distributed in placer as perfect crystals, wires, and rounded grains; and is occasionally found as nuggets weighing from 10 to 30 grams. Traces of gold are found in most rocks carrying pyrite. Gold is found in paying quantity in veins in Suyoc and Baguio, Mountain Province; Paracale and Mambulao, Ambos Camarines; and Aroroy, Masbate. It is found in paying quantity in placer in Suyoc, Mountain Province; Peñaranda district, Nueva Ecija; Umaeri, Tayabas; Paracale, Mambulao, and Malaguit, Ambos Camarines; Cansuran, Surigao; Hibong River, and other localities along the Agusan River, Mindanao; in Misamis Province; and in Mindoro.

Graphite—C.

Graphite is reported as occurring in "graphite clay" in Bulacan.

Guano—P_2O_5 with impurities.

Guano occurs as a coarse brownish earth in limestone caves in many parts of the Archipelago, principally along sea coasts. A small amount is collected, which is sold to Japanese exporters.

Gypsum—$CaSO_4$.

Gypsum occurs generally in small tubular crystals as incrustations on volcanic rocks near solfataras; also, in finely granular form in the Loboo Mountains, Batangas, Luzon. There is no production, and the quantity is apparently limited.

Hematite—Fe_2O_3.

Hematite is found in irregular "pockets" with magnetite, pyrite, chalcopyrite, and quartz in crystalline rocks of the eastern cordillera of Luzon; also, in veins cutting limestone. It occurs from Mambulao Bay, Ambos Camarines, to northern Bulacan, Luzon. The grade of this ore is excellent. It is smelted by Filipinos in crude blast furnaces to make plowshares.

Hornblende—$RSiO_3$, R being more than one of the elements Ca, Mg, Fe, Al, Na, and K.

Hornblende is abundant in many igneous rocks as black crystals varying in size from microscopic to 2 or 3 centimeters in length. It is of no economic value.

Hypersthene—$(FeMg)SiO_3$.

Hypersthene occurs in certain varieties of andesite in many localities. It is distinguished by its pleochroism (colorless to delicate pink) under the microscope. Hypersthene has no economic value.

Iddingsite—Exact composition not known.

Iddingsite occurs as alteration of olivine in rocks from three localities, Mount Mariveles, Bataan; Mindoro; and Batanes. The mineral is red. It has no economic value.

Ilmenite—$(Mg, Fe)TiO_3$.

Ilmenite is found in black-sand concentrates in many streams throughout the Archipelago, usually in small crystals and more or less rounded grains. It is not utilized.

Iridium—Ir (metallic).

The occurrence of iridium is the same as osmium.

Jasper—SiO_2.

Jasper occurs in fissile beds and in irregular masses. It contains remains of radiolarian tests. The color is brown to deep red.

Kalinite (**alum**)—$K_2SO_4 . Al_2(SO_4)_3+24H_2O$.

Kalinite occurs in mealy crusts around solfataras at Taal Volcano and elsewhere; apparently in small quantities.

Kaolinite—$Al_2O_3 .2SiO_2 .2H_2O$.

Kaolinite occurs in the Philippines usually as a solfataric decomposition product of andesitic rocks; it is rarely pure. In the region around Laguna de Bay, Luzon, it is found in irregular "pockets." Kaolinite is used to a moderate extent in making pottery and for a local paint, so-called "yeso," which is the Spanish equivalent for gypsum.

Labradorite—(See Plagioclase).

Leucite—$KAl(SiO_3)_2$.

Leucite occurs partially altered in certain very limited exposures of volcanic rock in the Aroroy district, Masbate. These rocks have from 8 to 10 per cent of potash, which might be made available for fertilizer.

Lignite—Various hydrocarbons.

Lignite is found in seams from 1 centimeter to 5 centimeters thick in many parts of the Archipelago. It usually crumbles into small cleavage cubes and air slacks. Its woody texture is seen best in weathered specimens. This mineral has been mined in the past, but there are no operations now.

Limonite.—$2Fe_2O_3 .3H_2O$.

Limonite is associated with hematite and is found near the surface; it occurs also in small pisolitic granules. It is distributed in small amounts throughout the Archipelago. Sometimes limonite is used in small quantities for paint.

Luzonite—Cu_3AsS_4.

Luzonite [1] is apparently a secondary ore of copper, and it is a special form of enargite. It forms in vugs and cracks in the vein. Luzonite is found in Mancayan, Mountain Province, and constitutes a large percentage of the enriched portion of the veins.

Magnesite—$MgCO_3$.

Magnesite occurs associated with serpentine in Ilocos Norte

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[1] Moses, *Am. Journ. Sci.* (1905), 277.

as a white, earthy mineral, which is efflorescent. No use is made of it.

Magnetite—Fe_3O_4.

Magnetite is widespread in small particles throughout the igneous rocks in the Philippines. It is also associated with the hematites of the eastern cordillera, Luzon. Fine octahedral crystals (No. 319) from San Miguel de Mayumo, Bulacan, Luzon, are in the collection of the Ateneo de Manila.

Magnetized iron ore—Lode stone. Apparently iron oxides.

This ore is found near Paracale, Camarines, and is also reported near Casiguran, Tayabas. No deposits are worked.

Malachite—$(Cu.\,OH)_2CO_3$.

No large crystalline samples of malachite are on record. This mineral is present in most of the copper deposits as a green coating.

Manganite—$MnO{\cdot}(OH)$.

Manganite occurs possibly with wad or pyrolusite in mineral veins, and often contains high values in gold. It is soft, and is derived from other manganese ores. It is found in several veins in Baguio and Suyoc, Mountain Province, and in Aroroy, Masbate. It has no economic value in the manner of its occurrence in the Philippines.

Marcasite—FeS_2.

Marcasite is similar to pyrite, but is whiter. It is apparently infrequent. Marcasite has been reported from Mancayan, Luzon.

Margarite—$H_2CaAl_4Si_2O_{12}$.

Margarite is a white mica occurring in certain schistose rocks of Ilocos Norte. No use is made of it, nor is there any production.

Mercury—Hg (metallic).

Mercury is reported to occur in small crevices and pockets on Mount Isarog, Albay, Luzon. A small phial of it is in the museum of the Ateneo de Manila.

Minium—PbO.

A large amorphous pink specimen of this mineral is in the museum of Santo Tomás University, marked "Filipinas;" no other data are given.

Molybdenite—MoS_2.

Molybdenite is found in characteristic form in steel-blue flakes and leaves in quartz veins, Loboo Mountains, Batangas Province, Luzon. Only a small amount is found.

Muscovite—$K_2O.3Al_2O_3.2H_2O$.

Muscovite occurs rarely in igneous rocks. It occurs more commonly in schists, particularly in a quartz muscovite schist in Ambos Camarines. There are no economic deposits of this mineral in the Philippines.

Niter—KNO_3.

Niter is said to be collected from certain caves on a small island near Surigao, Mindanao, and is used by natives for making gunpowder. This laboratory has no definite information regarding this substance in the Philippines, and its occurrence is to be doubted because of the heavy rainfall here.

Oligoclase—(See Plagioclase).

Olivine—$(Mg, Fe)_2SiO_4$.

Olivine occurs in many rocks in the Islands, particularly in small greenish yellow grains in basalt and in so-called picrites of Panay. It is of no economic value.

Opal—SiO_2H_2O.

Opal is found in small fragments, and occasionally in large pieces of jasper. It occurs in Ilocos Norte and various other localities, but is not of any commercial value as found in the Philippines. One pretty specimen showing "fire" is in the museum of Santo Tomás University.

Orthoclase—$K_2O.Al_2O_3.6SiO_2$.

Orthoclase occurs sparingly in some igneous rocks. It is of no economic use.

Osmium—Os (metallic).

Osmium occurs with gold, iridium, and traces of platinum in thin metallic plates in decomposed rock. The locality where the mineral is found is said to be Luzon.

Petroleum—Complex series of hydrocarbons.

Petroleum occurs as a very light, paraffin-base oil in shales in various parts of the Islands, notably in Bondoc Peninsula, Tayabas, Luzon, and in Cebu. Two wells, one shallow and one deep, have yielded a small amount of oil.

Philippsite—$(K_2, Ca)Al_2Si_4O_{12}+4\frac{1}{2}H_2O$.

Philippsite occurs in characteristic white, radiating or tuffed masses in Masbate. No economic use is made of it.

Pickeringite (magnesia alum)—$MgSO_4.Al_2(SO_4)_3+22H_2O$.

Pickeringite is found in long fibrous masses as efflorescence in the old Santa Barbara copper mine, Mancayan (Lepanto), Mountain Province, Luzon; it also occurs on Camaguin Island, Batanes.

Plagioclase—($NaAlSi_3O_8$ to $CaAl_2Si_2O_8$).

This series of closely related minerals is one of the commonest of all the constituents of igneous rocks in the Philippines. It embraces the following species: Albite, anorthite, andesine, and labradorite. It has no known economic value as such.

Platinum—Pt (metallic).

Platinum is found in minute flattened grains in placer-test borings near Peñaranda in Nueva Ecija; on the Mariquina River in Rizal Province, Luzon; and in Agusan Valley, Mindanao. There is no production in the Philippines.

Prochlorite—$H_4(Mg, Fe)_2Al_2SiO_9$.

Prochlorite occurs in dirty green leaves which are flexible but not elastic. It is found in the metamorphic area of Ilocos Norte, Luzon. No use is made of it.

Psilomelane—H_4MnO_5. The manganese is commonly replaced in part by barium or potassium.

Psilomelane occurs associated with pyrolusite. It is a very impure ore of manganese, often containing only 40 per cent of manganese. See pyrolusite.

Pyrite—FeS_2.

Pyrite occurs both massive and crystalline. The mineral appears as disseminated grains and as large crystals. Pyrite is often cupriferous. It is persistent in quartz veins and occasionally in calcite veins. Frequently it is one of the early minerals to crystallize. It is often associated with galena and zinc, but generally precedes them. Pyritization of vein walls occurs by reaction of the magnetite with H_2S gas from the fissure. Frequently this mineral is disseminated in volcanic rocks. Specimens of large secondary (?) crystals are in the Bureau of Science collection from Malaguit River, Camarines. Pyrite forms under conditions ranging from deep to surface. It is the most widely distributed metallic mineral. It is found in almost all rocks. This mineral is especially abundant in quartz veins, and is frequently associated with gold. There is no commercial use of pyrite in the Philippines.

Pyrolusite—MnO_2 with 2% H_2O.

Pyrolusite is the principal ore of manganese in the Philippines. It occurs in botryoidal or massive shapes; also, reniform. It is found as veinlets in andesite and as nodules from erosion of veins and possibly in beds. It is found in Ilocos Norte, Pangasinan, Bulacan, Tarlac, and Masbate. It is not exploited.

Pyroxene—$Ca(Mg, Fe)Si_2O_6$.

Pyroxene is a common constituent of pyroxene andesite, one of the chief rock types in the Islands. It occurs in small jet black crystals. It has no economic value.

Quartz—SiO_2.

Quartz is very persistent under conditions from deep seated to surface. It occurs in fine crystals in vugs under proper conditions; otherwise, it generally takes the form of jasper, chert, or siliceous sinter at the surface. It occurs in veins and as silicification of wall rocks. Two workable deposits only are known: (1) Siliceous spring deposits, Baguio, and (2) beach sand, Looc, Lubang Island. Quartz is used locally for road material and concrete in Baguio and at Looc.

Realgar—AsS.

Realgar occurs as characteristic red crystals on a yellow coating of orpiment on pieces of slag (?) from the old Santa Barbara furnace at Mancayan, Luzon. As far as we know it does not occur in a natural state in the Philippines. Specimens, No. 59, of realgar are in the museum of the Ateneo de Manila.

Rhodochrosite—$MnCO_3$.

Rhodochrosite occurs as a gangue mineral in auriferous calcite veins of Benguet. It is a primary mineral; it was probably leached from wall rocks by the ascending solutions and was later deposited with the calcite. Rhodochrosite is of no economic use.

Rutile—TiO_2.

Microscopic crystals occur in some of the metamorphic rocks from Ilocos Norte associated with actinolite, muscovite, etc. Rutile has no economic value.

Salt—NaCl.

Salt is deposited as incrustation from brackish carbonated springs in Mountain Province, Luzon, notably at Asin. It is used by the Igorots.

Sanidine—$(K, Na)AlSi_3O_8$.

Sanidine occurs in small crystals and grains. This "glassy feldspar" is a dominant constituent of the andesites of many peaks in Zambales Mountains and of Mount Apo, Mindanao. It is of no economic value.

Sardonyx—SiO_2.

A specimen of this, No. 174, from Baganga, Mindanao, is in the collection of the Ateneo de Manila.

Sericite—$3Al_2O_3.6SiO_2.2H_2O$.

Sericite is one of the micas occurring in the schists of Ilocos Norte and Zamboanga Peninsula, Mindanao. It occurs in small gray-blue silky flakes. It is of no economic use.

Serpentine—$H_4(Mg, Fe)_3Si_2O_9$.

Serpentine, associated with pyroxenites and peridotites in more or less structureless masses, is found in Ilocos Norte and other localities. It is a greenish mineral. It occurs usually as asbestiform minerals. There is no production in the Philippines.

Silvanite—$(AuAg)Te_2$.

Silvanite occurs intimately mixed with the lead telluride altaite in quartz and calcite stringers in a contact between a slaty formation and a feldspar-porphyry dike.

Silver—Ag (metallic).

Silver occurs alloyed with gold. Wire silver is very rare in the Philippines, being reported only from Suyoc and Bosoboso, Rizal Province. Absence of native silver is due to excessive rainfall probably, as most silver mines where silver is secondary are in desert countries. Some silver associated with galena is found in Cebu and other localities.

Sphalerite—ZnS.

Sphalerite occurs massive or as small crystals, always associated with lead and pyrite. Like the other sulphides, it favors the quartz veins; it forms under conditions of moderate depth. It is found in practically all localities where galena is found (see galena). Sphalerite is not found in economically valuable quantities in the Philippines, although widely found in many veins. It is not utilized.

Stibnite—Sb_2S_3.

Stibnite occurs in characteristic fibrous masses. There is only one specimen in the Bureau of Science collection from Batangas Province, Luzon.

Sulphur—S.

Sulphur occurs more or less pure in characteristic yellow crystals around solfataras and also in a very impure state mixed with volcanic ash on Camiguin Island (both northern and southern), Taal Volcano, and Sorsogon, Luzon; on Mount Apo, Mindanao; and on Biliran Island. No sulphur is mined at present, but some mining was carried on formerly on Biliran.

Talc—$3MgO.4SiO_2.H_2O$.

There are small amounts associated with mica and actinolite in the metamorphic region of Ilocos Norte, Luzon. No local use is made of this mineral.

Tetrahedrite—$4Cu_2S.Sb_2S_3$.

Tetrahedrite occurs as flint-gray to tin-black crystals. It is found at the old Santa Barbara mine, Mancayan, Lepanto, Luzon.

Titanite—$CaTiSiO_5$ or $CaO.TiO_2.SiO_2$.

Titanite occurs as characteristic wedge-shaped crystals associated with the iron-ore deposits of Bulacan.

Topaz—$(AlF)_2SiO_4$ or $(Al(F, OH)_2)SiO_4$.

Topaz occurs in small (2-4 millimeters) pink, yellow, and colorless orthorhombic crystals. It is found in placers of Paracale River, Ambos Camarines.

Tremolite—$CaMg_3(SiO_3)_4$.

Tremolite occurs in long white to greenish fibers associated with serpentine and asbestos in Ilocos Norte. It could be used commercially.

Uralite—Composition same as pyroxene save for slight change in magnesium and calcium content.

Uralite is a green alteration product of pyroxene, and is found in certain igneous rocks called metadiorites, which are altered gabbros.

Vermiculite—Hydrated mica.

Vermiculite is an earthy mica found in the metamorphic area of Ilocos Norte. It has no economic value.

Wad—An earthy mixture of manganese oxides.

Wad is found in association with psilomelane and pyrolusite. It is of no economic importance now.

Wernerite—Intermediate between $Ca_4Al_6Si_6O_{25}$ and $Na_4Al_3Si_9O_{24}Cl$.

Wernerite is a white fibrous silicate, and occurs in veinlets in greenstone in Aroroy district, Masbate. No economic use is made of it.

Wolframite—$(FeMn)WO_4$.

Wolframite is a heavy, black, crystalline mineral. Specimens are said to have been found in Antique Province, Panay. There is no economic development.

Zeolite—Composition is uncertain. $RAl_2Si_{10}O_{24}$.

Zeolite occurs as a fibrous secondary product in the decomposition of certain rock minerals, principally feldspars, and in amygdoloidal cavities throughout the Islands. This mineral has no known use.

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GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF THE INTERIOR
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1914

ISSUED BY THE DIVISION OF MINES
BUREAU OF SCIENCE

MANILA
BUREAU OF PRINTING
1915

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Fig. 1. Digging ladder of the Malaguit dredge on Malaguit River, Camarines, showing the close-connected, 5-cubic foot buckets filled to capacity.

Fig. 2. Construction work on the new 10-stamp mill of the Benguet Consolidated Company, Baguio, Mountain Province. Assay office to left, mill site near center, storehouse to right, pipe line and haulage tunnel from mine in background.

PLATE I.

Government of the Philippine Islands
Department of the Interior
Bureau of Science

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1914

ISSUED BY THE DIVISION OF MINES
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VICTOR E. LEDNICKY, B. S., *Mining Engineer.*
———, *Geologist.*
PIO MOSKAIRA, *In charge of map section.*

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MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1914

REVIEW OF PHILIPPINE MINING IN 1914

By WALLACE E. PRATT

The year 1914 was characterized in Philippine mining by the growing ascendency of gold mining over other branches of the mineral industry. Among the metals only gold (with the associated silver), iron, and an insignificant quantity of lead have been marketed.

The eminently satisfactory progress in gold mining, both lode and placer, is discussed on another page. The past year was marked by the introduction of legislation providing for a royalty on the gold output—a proposal which met with strenuous opposition on the part of the operators. The original bill introduced early in the year involved a 3 per cent royalty upon the gross output. This bill, when it came before the Legislature, was referred to a committee, with the result that at the end of the year a revised bill was presented which levied a 5 per cent royalty on the gross output of precious and semiprecious metals. After several public hearings this bill was modified, and finally a 1.5 per cent royalty was imposed on the gross output of gold, the tax becoming effective on January 1, 1915.

There was no perceptible progress during 1914 in the attempts of claim holders to interest capital in the copper properties. Outcrops of copper ore containing a notable percentage of metallic copper were discovered in Zambales Province east of San Marcelino, and there has been considerable activity in prospecting the deposit. The Mancayan copper region has remained quiescent, the only activity there being the annual assessment work necessary to continue the title of the locators. The owners of the old Santa Barbara copper mine at Mancayan released to the chief of the division of mines, Bureau of Science, a statement that the estimates of the engineers of the Tellus Syndicate, Frankfort, Germany, who examined the property as possible purchasers, included 225,870 tons of ore, carrying an average of 5.22 per cent of copper, and approximately 150,000 tons containing 1.75 per cent copper.

The Filipino iron-smelting industry in Bulacan has continued in a normal manner. An attempt to inaugurate a similar operation on the more accessible iron ores at Mambulao has not yet proved successful. The most important thing to be recorded for iron mining is the discovery by Mr. H. F. Cameron, engineer for the department of Mindanao and Sulu, of an extensive deposit of lateritic iron ore in Surigao Province.

Coal mining, which has been inactive for several years, was not resumed in 1914. The exploration of the Uling field in Cebu, which was in progress a year ago, was discontinued for financial reasons previous to the outbreak of the European war. The work had progressed far enough to establish the continuity of the principal bed, which is a little more than 2 meters in average thickness, over a distance that promises a commercially important tonnage. The Danao (Cebu) field, which is controlled by Mr. D. M. Carman, under Spanish concessions, has been reexamined, and mining may be resumed on some of the claims.

The petroleum field in Bondoc Peninsula, Tayabas Province, remains unexplored so far as actual drilling is concerned. A report on this field, summarizing the results of studies made at various times by five different geologists, concludes that the chance of encountering petroleum in commercial quantity is great enough to warrant the drilling of a series of test wells. The discoveries of asphaltites and associated petroleum in northern Leyte have been multiplied, until more than a score of outcrops and seepages distributed over an area 20 kilometers long have been reported. A local company, the Leyte Asphalt and Mineral Oil Company, has been incorporated and controls a number of the important mineral locations.

In other branches of mining there is little to record. The European war, with the resulting curtailment of supplies of ferromanganese, has reawakened interest in the possibilities of Philippine manganese ore. The deposits of bat guano in limestone caves throughout the Islands are being utilized locally at an increasingly large number of places as fertilizer. The construction of the factory of the Rizal Cement Company at Binangonan, Rizal, continued throughout the year, and production will begin in 1915.

In general, the Philippine mining industry was normal during 1914, in spite of the fact that the year was one of retrenchment in most lines of activity.

STATISTICS OF MINERAL PRODUCTION IN THE PHILIPPINES IN 1914

By VICTOR E. LEDNICKY

TABLE I.—*Mineral products of the Philippine Islands, for the calendar years 1907 to 1914.*

Products.	1907		1908		1909	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Metallic:		*Pesos.*[a]		*Pesos.*		*Pesos.*
Iron ....metric tons..	132	19,536	96.5	17,500	78	31,078
Silver[b] ....fine ounces..	83	110	2,350	2,491	3,000	3,120
Gold ....do	4,540	187,647	10,510	434,500	11,978	495,194
Copper ......kilograms fine..			91	52		
Manganese						12,500
Total value of metallic		207,293		454,543		541,892
Nonmetallic:						
Coal ....metric tons..	4,123	26,799	10,035	77,166	30,336	197,184
Clay products[c]				421,628		422,840
Lime[c]				20,000		69,656
Sand and gravel				206,360		325,050
Stone				149,930		311,177
Salt[c] ....metric tons..						375,368
Mineral waters ....liters..			268,440	53,688	401,000	80,200
Total value of nonmetallic..		26,799		928,772		1,781,475
Grand total		234,092		1,383,315		2,323,367

Products.	1910		1911		1912	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Metallic:		*Pesos.*		*Pesos.*		*Pesos.*
Iron ....metric tons..	50	20,023	37	29,159	141	49,272
Silver[b] ....fine ounces..	1,800	1,944	3,383	3,606	7,121	8,664
Gold ....do	7,469	308,860	9,190	379,906	27,582	1,140,424
Copper ...... kilograms fine..	1,809	464	1,100	600		
Manganese						
Total value of metallic		331,291		413,271		1,198,360
Nonmetallic:						
Coal ....metric tons..	28,655	176,255	20,000	130,000	2,720	20,200
Clay products[c]		430,000		450,000		453,000
Lime[c]		70,000		90,000		92,026
Sand and gravel		293,456		477,344		468,758
Stone		372,575		665,795		651,049
Salt[c] ....metric tons..		380,000	18,333	550,000	19,147	574,511
Mineral waters ....liters..	230,000	46,000	300,000	60,000	264,871	55,849
Total value of nonmetallic..		1,768,286		2,413,139		2,315,385
Grand total		2,099,577		2,826,410		3,514,745

Footnotes are at the end of the table, page 10.

Table I.—*Mineral products of the Philippine Islands, for the calendar years 1907 to 1914*—Continued.

Products.	1913 Quantity.	1913 Value.	1914 Quantity.	1914 Value.
		Pesos.		*Pesos.*
Metallic:				
Iron ....metric tons..	227	64,471	199	56,274
Silver[b] ....fine ounces..	....	....	10,000	9,878
Gold ....do....	42,011	1,736,724	58,235	2,349,267
Copper ....kilograms fine..	....	....	....	....
Manganese	....	....	....	....
Total value of metallic	....	1,801,195	....	2,415,419
Nonmetallic:				
Coal[d] ....metric tons..	....	....	....	....
Clay products[c]	....	460,000	....	465,000
Lime[c]	11,050	102,700	11,000	100,000
Sand and gravel[e]	689,011	595,645	723,461	625,429
Stone[e]	197,039	350,041	206,890	367,543
Salt[c] ....metric tons..	19,500	575,000	20,000	590,000
Mineral waters ....liters..	270,000	60,000	293,381	50,000
Total value of nonmetallic	....	2,143,386	....	2,197,972
Grand total............	....	3,944,581	....	4,613,391

[a] One peso Philippine currency equals 50 cents United States currency.

[b] The gold bullion produced carries from 5 to 30 per cent of silver as a natural alloy.

[c] The manufacture of this product is a household industry in a very large part of the Islands. Statistics are, therefore, not available, and estimates are approximate.

[d] No economic production.

[e] Production of the Bureau of Public Works, which is the largest single producer, estimated for 1914.

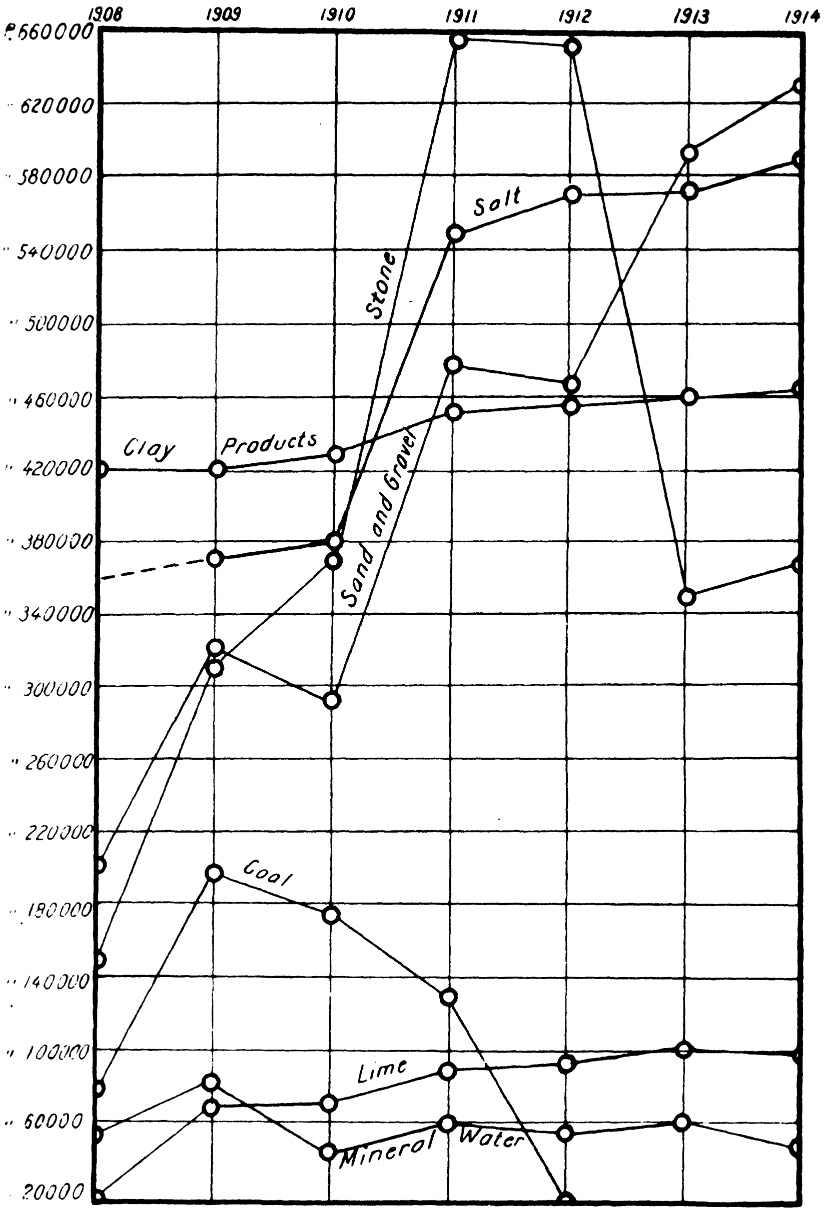

FIG. 1. Curve of production of nonmetallic minerals.

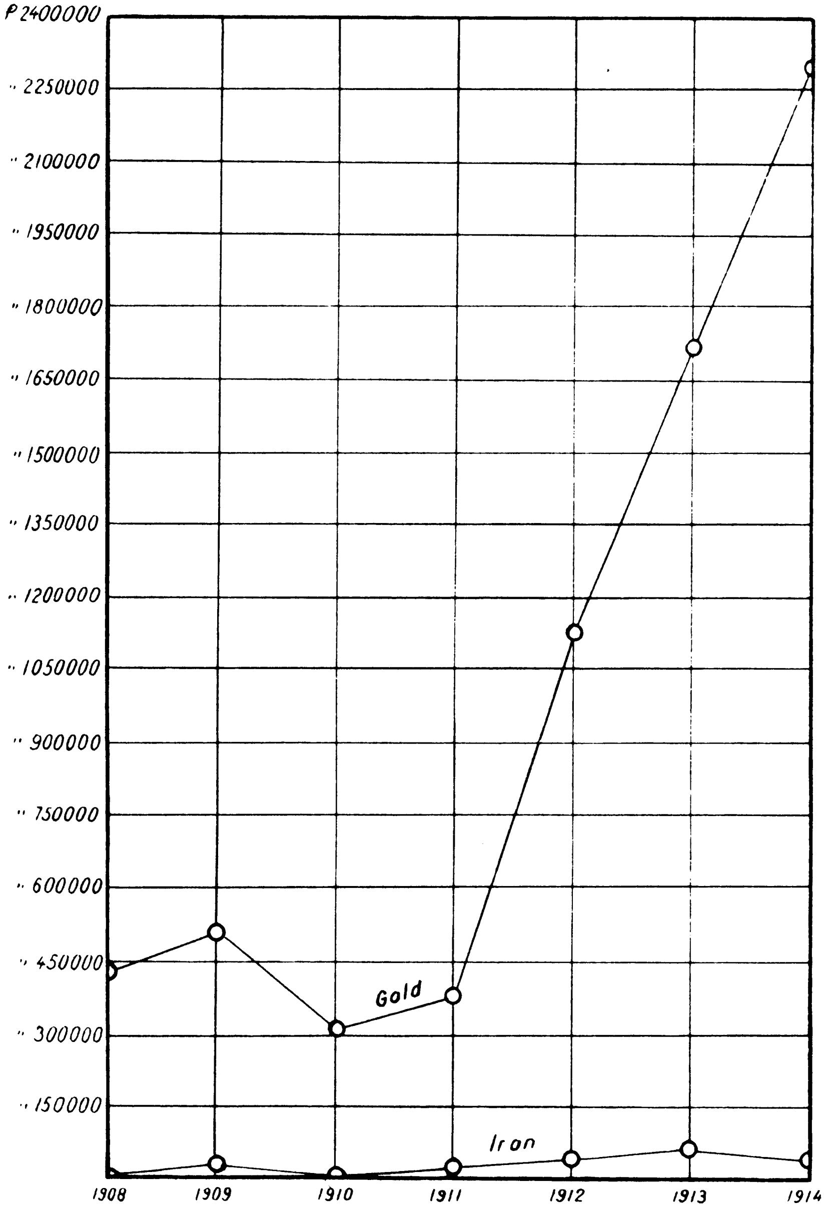

FIG. 2. Curve of production of metallic minerals.

GOLD PRODUCTION OF THE PHILIPPINE ISLANDS IN 1914

By WALLACE E. PRATT

According to figures prepared by the division of mines, Bureau of Science, based on the returns from gold producers and gold exporters, the output of gold for the Philippines during the year 1914 amounted to 2,349,267.21 pesos.[1] The preliminary estimate of 2,406,867.21 pesos issued by the Bureau of Science contained a duplication of mine returns and exporters returns amounting to 57,600 pesos; this error is corrected herewith. The production for 1913 was 1,736,724 pesos, from which it appears that the production for 1914 was nearly 36 per cent greater than that for 1913.

The gold actually exported from the Philippine Islands in 1914 amounted to 2,338,595.74 pesos. Of the remainder, something more than 10,000 pesos, about 1,000 pesos were used in making jewelry, and the rest passed into the hands of small buyers, most of whom are Chinese, in the various districts.

As usual the estimate of the Bureau of Science is somewhat greater than that given out by the United States mint for the gold production of the Philippines. The mint reports the receipt of 2,120,000 pesos' worth of Philippine gold during 1914. The difference between the local estimate and the figures of the United States mint represents gold which was exported to Europe or Japan, gold in transit at the end of the year, and gold not exported.

A little more than one half of the Philippine production, or about 1,220,000 pesos, came from quartz mining at Aroroy, Masbate, where the Colorado, Syndicate, and Keystone mines are the principal producers. The P. A. Schwab property at Aroroy also produced some gold, and other prospects have been actively developed.

Dredging is responsible for about 1,030,000 pesos, or nearly 44 per cent of the 1914 output. The principal producers among the dredging companies are all in the Paracale-Mambulao district in Camarines Province and include the Gumaus Placer Company,

[1] One peso Philippine currency equals 50 cents United States currency.

the Paracale Bucket Dredging Proprietary, Limited, the Malaguit Dredging Company, the Philippine Dredging Syndicate, and the Maximelo Dredging Company. Seven dredges have been in operation in this district during the past year, although not all of these have worked constantly. One dredge is working on Umari River in Tayabas Province, on the eastern coast of Luzon.

The remaining 99,000 pesos of the 1914 output came from northern Luzon, about 60,000 pesos from Benguet, the balance from Mancayan. In Benguet the Headwaters Mine has been operating during a part of the year under lease to L. O. Hibberd, and the Camote-Clayton with its three stamps has been producing under the management of John T. Reavis. In southern Benguet Geo. W. Mentzer, with another small mill, has produced a little gold. The Mancayan gold came from the Palidan slide and was recovered in a primitive fashion by Filipinos.

The year 1915 should show a materially increased gold production. New dredges are under construction for some of the operating companies at Paracale, and the Mambulao Placer Company will enter the dredging field, although it may not begin to produce before the beginning of 1916. The Masbate output should expand, since neither the Syndicate nor the Keystone had reached the producing stage until some time after the first of the last year. In Benguet the 10-stamp mill of the Benguet Consolidated Company will have begun to operate, and in Surigao the hydraulicking operations of the Cansuran Placer Company should yield a considerable return.

GOLD MINING IN THE VARIOUS DISTRICTS IN 1914

By WALLACE E. PRATT

THE AROROY DISTRICT, MASBATE

The leading position among the Philippine gold-mining regions is again allotted to Masbate for the year 1914, making a record for that island of three consecutive years as the foremost Philippine mining district.

The Colorado Mine, the oldest consistent producer in the district, continued operation throughout the year. The mill (20 stamps) has been adjusted and improved until the daily tonnage of ore treated is very close to 150 tons against 119 tons for the preceding year. Full descriptions of the mine and mill have appeared in previous numbers of this bulletin as have also descriptions of the other mills in the district. The three largest mills employ the all-sliming cyanide process; in the Colorado Mill, after coarse crushing, the ore is reduced by stamps followed by tube mills; in the Syndicate Mill the crusher is followed by a Hardinge ball mill which discharges to Hardinge pebble mills; while at the Keystone two Lane slow-speed mills are employed for fine grinding.

The Syndicate Mining Company began milling ore in March, 1914, and the operation has been continuous and successful from the start. The mill has a nominal capacity of 50 tons per day, but is being enlarged to treat 100 tons per day.

The Keystone Mining Company also began milling operation during the year and has attained a stage of steady production. Development work is said to have revealed a new vein carrying values unusually high for the Aroroy district.

P. A. Schwab has operated a small stamp mill on free-milling ore and is responsible for some of the year's output. Prospecting and exploration have gone on elsewhere over the district, and it will not be surprising if other producing mines are established in the Aroroy district within the next few years. The output of this field in 1915 should exceed that recorded for 1914.

THE PARACALE–MAMBULAO DISTRICT, CAMARINES

Next to the Aroroy district in point of gold output in 1914 is the gold-dredging region of Mambulao Paracale and Mambulao, Camarines. The lead which the Aroroy district held in 1913 was reduced during 1914—from about 33 per cent to about 22 per cent of the total yield of the dredges.

The Gumaos Placer Company operated continuously throughout the year. Its dredge, built by the New York Engineering Company and described in previous numbers of this bulletin, has achieved an enviable record during the period over which its operation extends. On an original investment of 500,000 pesos [1] the company has paid in dividends during 27 months of operation the sum of 535,000 pesos, or 107 per cent. The generally non-uniform character of the dredging ground in this district is exemplified in the record of the Gumaos dredge; the average value per cubic meter for different monthly runs varies from 6 centavos to 1.66 pesos. The average value for the whole period of operation has been 64 centavos per cubic meter. The cost of operation, according to the company's figures, is about 24 centavos per cubic meter dredged. The average fineness of the bullion smelted is 873. The depth to bedrock varies up to 17 meters but has averaged about 11 meters. The gold recovered is fine and very sharp and angular. It is confined to a layer of wash usually less than 2 meters thick immediately overlying bedrock; the overburden is largely clay. The following table, reproduced from the annual statement for 1914 by Frank B. Ingersoll, general manager for the company, summarizes the work of the dredge to date.

TABLE I.—*Record of operation from October 1, 1912, to December 31, 1914, both dates inclusive.*

Month.	Hours worked.	Yardage.	Bullion.	Value.	Average value per cubic yard.	Dividends paid.	
						Amount.	Rate.
1912.			*Ounces.*	*Pesos.*	*Pesos.*	*Pesos.*	*Per cent.*
October	401	43,492	513.75	18,543.47	0.4263		
November	538	57,638	1,639.30	59,194.39	1.0270		
December	560	60,000	2,011.64	72,611.20	1.2101	50,000	10
1913.							
January	410	58,080	1,002.06	36,170.36	0.6214	50,000	10
February	436	57,500	1,001.90	36,164.59	0.6289		
March	323	42,000	1,496.67	53,923.78	1.2838	25,000	5
April	560	130,000	1,137.92	41,074.91	0.1621	50,000	10
May	540	72,000	1,615.15	58,300.91	0.8097	25,000	5
June	515	68,000	998.85	36,054.48	0.5302	25,000	5
July	400	50,000	451.64	16,302.10	0.3260	25,000	5
August	414	50,000	218.18	7,876.30	0.1575	25,000	5
September	484	72,700	369.28	13,330.00	0.1833		
October	520	91,000	903.83	32,625.26	0.3585		
November	466	58,000	737.83	26,636.73	0.4597	25,000	5
December	287	65,000	634.90	22,918.89	0.3372		

[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

TABLE I.—*Record of operation from October 1, 1912, to December 31, 1914, both dates inclusive*—Continued.

Month.	Hours worked.	Yardage.	Bullion.	Value.	Average value per cubic yard.	Dividends paid.	
						Amount.	Rate.
1914.			*Ounces.*	*Pesos.*	*Pesos.*	*Pesos.*	*Per cent.*
January	414	67,000	648.82	23,419.43	0.3495	25,000	5
February	508	75,000	643.34	23,221.93	0.3096		
March	544	92,000	131.36	4,741.96	0.0515	25,000	5
April	489	87,000	901.29	32,531.67	0.3739		
May	521	76,000	1,744.40	62,965.10	0.8284		
June	276	40,000	697.13	25,163.70	0.6290	25,000	5
July	495	82,500	1,676.51	60,513.34	0.7334	40,000	8
August	517	82,000	2,013.02	72,659.30	0.8616		
September	510	78,000	401.72	14,500.70	0.1859	100,000	20
October	531	86,000	584.73	21,106.17	0.2454		
November	475	54,552	798.04	28,745.00	0.5269		
December	455	55,251	302.24	10,909.56	0.1974	20,000	4
Total	12,589	1,850,713	25,276.16	912,205.23	(a)	535,000	107

[a] Average extraction per cubic yard, 0.4929 peso.

The Paracale Bucket Dredging Proprietary, Ltd., and the Philippine Dredges, Ltd., closely associated Australian corporations, had 4 dredges at work during 1914. One of these started in November, and another lost a great deal of time as a result of litigation over title to the ground upon which it was situated. In spite of obstacles, however, the year's record is good, and much credit is due Mr. Wm. Telford, the general superintendent for the two companies.

The Malaguit Dredging Company placed a new dredge on Malaguit River early in 1914. Some time has been lost in getting into proper running order, but the dredge has recovered a gratifying amount of gold and will undoubtedly do better as the operation becomes established.

The Philippine Dredging Syndicate and the Maximelo Dredging Company each operated one dredge in 1914. About the middle of the year the former company finally dismantled its old Risdon dredge, which was built in Masbate in 1905, moved over to the Paracale district in 1908, and has been digging on Malaguit River since that time.

The Mambulao Placer Company is reported to have obtained exceptionally high values from the tests of its dredging property at the head of Mambulao Bay, and a New York engineering company's dredge will be erected at Mambulao during the coming year.

Several dividends were declared by the dredging companies during the past year, and the industry appears to be in a healthy condition.

Quartz mining in Camarines is at present confined to the Tumbaga Mine, which is held under lease by Messrs. Le Duc and Dudley.

THE BAGUIO DISTRICT, MOUNTAIN PROVINCE

Mr. C. M. Eye, a well-known American mining engineer, with previous experience in the Philippines and wide experience in the United States and Mexico, has recently returned to Benguet. Reviewing general conditions in the Baguio district, Mr. Eye is moved to make the following statement which, in view of his standing as a mining engineer, is significant:

> There are a number of promising properties on which very little work has been done, yet with proper and wise investment may prove to be good mines. No property in the district has been developed to any depth, but the showing thus far made is much better than on many valuable properties in the States, and has been accomplished with less expenditure.

The outstanding features of the year's progress in the Baguio district are the construction of the new Benguet Consolidated Mill, the successful operation of the Headwaters Mine under lease to L. O. Hibberd, and the erection of a small mill on Acupan Creek by C. H. Hulbert and associates. The last-named enterprise had not reached a producing stage at the end of the year. It is known that rich ore is to be obtained on the claims whose development is contemplated.

The 3-stamp mill on the Camote-Clayton property, which has been operating for about three years under the management of John T. Reavis, continued to produce throughout the last year.

The Headwaters Mine with its 10-stamp mill, after a period of inactivity, was leased about the middle of 1914 to Mr. Hibberd, who is reported to have succeeded in saving about 300 ounces of gold per month by amalgamation. It is probable that his success will tend to reëstablish the Headwaters property.

Progress on the erection of the new mill in the Benguet Consolidated property has been rapid, and the mill will probably begin operation by July, 1915. Mr. Eye, the engineer who designed and is now erecting the mill, has courteously supplied the following details concerning it and the reopened mine.

> The new mill will be of the all-sliming, cyaniding type, and its equipment will include an 8 by 12 Hercules-Blake crusher; 10 Hendy stamps of 1,050 pounds' weight with high, narrow, discharge mortars set on wooden blocks; 1 Dorr duplex classifier in closed circuit and on the same level with a Denver Engineering Works 6- by 10-foot tube mill; elevator from

classifier to primary Dorr thickeners in a 25- by 12-foot tank; 3 Dorr agitators in series in 14- by 12-foot tanks for continuous work; 4 secondary thickeners in series in 25- by 12-foot tanks, arranged to work on the continuous discharge, counter-current system; 1 clarifying tank with canvas leaf filters and wet vacuum pump; 3 double-lined, 7-compartment zinc boxes made by the Atlantic, Gulf & Pacific Company in Manila; 2 Gould triplex pumps for solution transfer, each with a capacity of 75 gallons per minute; a battery of Gould diaphragm pumps between thickeners for pulp transfer; an automatic tailings sampler following the line of tanks; and a complete clean-up equipment, including a Case oil-fired tilting furnace. The solution flow is recorded automatically in tons per 24 hours by means of a recording gauge on a small tank from which the solution escapes through a calibrated standard orifice. All tankage is of corrugated steel, this choice of material being governed partly by the saving made possible in freight charges.

Power will be distributed by electric motors; the stamps are on a 25-horsepower back-geared motor, and the tube mill is operated through a friction clutch by an ordinary 50-horsepower motor. The total motor horsepower is 105, while the maximum load with the crusher in operation is estimated at 100 horsepower. Hydroelectric power is to be generated by a Pelton-Doble wheel direct connected to a 180 kilowatt generator at a site downstream from the mill. The pipe line is 1,830 meters long and yields a head of about 92 meters gross, 79 meters effective, with a flow of about 0.14 second-meter. The diversion weir is made of logs on a concrete footing and is 6 meters high and 14 meters long. The current will be transmitted at 2,380 volts over a transmission line 730 meters in length to the mill, where the voltage will be stepped down to 220.

A new drainage tunnel is being driven from the lowest practicable point to drain the old levels. This tunnel will be about 150 meters in length when it reaches the lode. A new tunnel will also be driven to the upper levels of the old mine from the new mill site, a distance of about 75 meters. An old crosscut which is being extended to meet this tunnel recently passed through 1.4 meters of ore, which assayed 180 pesos per ton. Concentrates from this ore assayed more than 4,000 pesos per ton. The new mill tunnel will afford ready access to the upper levels on both the foot- and hanging-wall sides of the vein at a point where ore shoots are known to occur. The vein is being developed eastward along the hanging wall, and two new crosscuts have already been driven through the vein at distances of 15 and 30 meters east of the end of the mill tunnel. The first of these crosscuts revealed 2 meters of ore assaying 160 pesos per ton in gold, and the second one (farther east) 3 meters of ore assaying more than 70 pesos per ton. On the level of the old drainage tunnel, which reaches the vein at an elevation about 25 meters lower than the new mill tunnel, there are about 300 meters of old workings which are now flooded but will be unwatered by the new drainage tunnel. There are workable values on both the foot- and hanging-wall sides of the vein in these old workings.

From the foregoing data it appears that the new mill will undoubtedly establish the value of the Benguet Consolidated property, which has been idle during the last four years following the destruction of its mill for the second time by floods. The new mill is situated on a site which will be safe from floods under all conditions.

THE CANSURAN DISTRICT, SURIGAO

Toward the end of the year 1914 the Cansuran Placer Company began hydraulic mining operation at a point from 10 to 12 kilometers south of the town of Surigao on property leased from the Surigao Mining Company. Mr. R. Y. Hanlon, upon whose report the property was taken over, made a series of 181 tests by sinking shafts through the gravel to bedrock and panning regular vertical sections from surface to bedrock. He delimited in this manner several blocks of territory, adjacent to each other although not contiguous, with an aggregate area of 131 hectares. Over this area he obtained an average value of 57 centavos per cubic meter, the average depth to bedrock being 3.5 meters. All this ground is at such an elevation that water for hydraulicking purposes can be brought on to it under a head ranging from 40 to 100 meters.

Hydraulicking is now in progress on the ground tested by Mr. Hanlon. Water is obtained from Tuganaan River and is conveyed a distance of about 1.8 kilometers by ditch, flume, and pipe line. According to the engineer's estimates 1,000 miners inches (0.70 cubic meter per second) of water are available. The flume is 1.2 meters wide, has a fall of 1.7 per cent, and is built of native wood. At present the water is stored in a reservoir which is about 46 meters above the monitors. Another larger reservoir is under construction which will afford a head of about 100 meters; water can also be drawn from the flume directly into the pipe line under a head of about 100 meters. The main pipe line is 0.61 meter (24 inches) in diameter, the branches to the monitor being reduced appropriately. Two 6-inch monitors and one 7-inch monitor are in place, although there is insufficient water just at present to operate all of them continuously. The present sluices are 73 meters long, 1.5 meters wide, and are riffled with hardwood blocks 0.3 meter (12 inches) square set with a space of 2.5 centimeters (1 inch) between each cross tier. There is at present a length of about 100 meters of bedrock sluice ahead of the sluice boxes.

The company has installed a small air compressor and uses 3 hammer drills for breaking up the larger bowlders. A logging engine and movable cableway serves to remove rocks too large to go through the sluices. A small Pelton-Doble wheel on a separate pressure line furnishes power for lights, refrigerating plant, and a small sawmill with which the timber cleared ahead of the giants is sawed into marketable lumber.

The last year has been exceptionally dry in Surigao, and the streams are unusually low. Consequently water for hydraulicking has been insufficient in quantity. An area of about 2 hectares has been washed, but it has not yet been possible to clean up.

MINOR DISTRICTS

The Palican slide near Mancayan, Mountain Province, was the source of about 40,000 pesos' worth of gold in 1914. This slide has been worked for several years by Filipinos, who gouge out a quartz ore exposed in the face of the slide, crush it as best they can, and pan out the gold in near-by streams. It is said that several hundred people are at work here during about three months of the year. The output is purchased locally by three dealers, who dispose of it through the banks in Manila.

In the Lubang district in southern Benguet there are two properties, one equipped with 3-stamps and the other with a small Huntington mill, both of which are producing a little gold by amalgamation. This district is described on another page.

Several engineers have been employed during the greater part of the year testing placer gold areas in Mindanao for American capital. One party spent several months in the vicinity of Lianga, Surigao, and another party is working near Santiago, Butuan. Both these districts are known to have produced some gold in the past. Mr. August Heise is responsible for the thorough exploration that is now being performed.

In addition to the hydraulicking operation of the Cansuran Placer Company in Surigao Province, the Surigao Mining Company is developing several lodes in the hills immediately above the placer ground. On the Canimon claim a tunnel has been opened on a dark-colored quartz ore in andesite. This ore carries gold, and occasionally small vugs in the quartz contain needles of an antimony-lead mineral, which is probably jamesonite. The occurrence of jamesonite has not hitherto been known in the Philippine Islands. On the Allen claim recent work has revealed the presence of small stringers of quartz and, less commonly, of calcite in an indurated shale. The shale itself is impregnated with pyrite and appears to carry gold. Although several classes of ore have been encountered by the Surigao Mining Company, some of which contain good values, the work has not progressed far enough to develop any ore body.

C. A. Briggs is prospecting several leads on the site of the old Filipino workings at Tinabingan, Placer. Mr. Briggs has driven tunnels on several small veins in this district and has recently discovered a lead about 2 meters in width made up of a network of closely intersecting stringers of quartz in silicified andesite. A sample taken by Mr. Briggs and believed by him to represent the entire thickness of this lead showed, upon assay, a gold content of 25 pesos per metric ton. Although the mineralization at Tinabingan is characterized throughout by narrow quartz stringers, the different leads show some regularity in that their strike is uniformly east-northeast. The country rock is andesite and andesite-breccia.

The gold ores on Panaon Island, Leyte Province, which have been known for many years and were examined by an American engineer as early as 1883, are being reëxplored by A. Villiger in the interest of local capital. Mr. Villiger's work has revealed the presence of a new vein which is more promising than the ore encountered in the old workings.

The placer deposits on Binabay River, a tributary of Baco River in the northern part of Mindoro, were the scene of a small gold rush during the past year, and numerous claims were located. The gold on the Binabay is coarse and well rounded. The nature of the country is such that dredging would not be possible, although it might be feasible to hydraulic some of the ground. Much of the gold in specimens submitted to the Bureau of Science is coated with a film of mercury, yet the prospectors maintain that the gold was recovered without the use of mercury. A number of those interested in Binabay River district pooled their holdings and gave an option to purchase to an Australian company. The option was not taken up, however, ostensibly because of the adverse mining legislation which went into effect at the close of the year.

PRODUCTION OF IRON AND NONMETALS IN 1914

By WALLACE E. PRATT

The statistical table on another page shows the quantities and values of the various nonmetals and of iron produced during the year 1914. The production of iron in 1914 was not as large as that of 1913, but is considerably greater than that of 1912, and if it be remembered that practically all the iron smelted is cast into plowshares and points and that the past year was generally a season of drought, during which less than the usual amount of plowing was done, the record for 1914 cannot be considered bad.

The iron smelted from Philippine ores all comes from Bulacan Province, and the industry is entirely in the hands of Filipinos. The ore deposits and the primitive process of smelting have been described elsewhere.[1] Ten operators contributed to the 1914 production, seven from within the jurisdiction of the town of Angat, Bulacan, and three from San Miguel, Bulacan. The output consisted of 49,474 pairs (*pares*) of plowshares and plowpoints. All the operators report that the demand has been light.

According to the report of the Collector of Customs the imports of pig iron in 1914 amounted to 1,250 metric tons valued at 47,538 pesos,[2] and the imports of manufactures of iron and steel, including only rails, bars, sheets, and structural steel, were 45,457 metric tons valued at 4,561,000 pesos.

The production of nonmetals was normal during the year 1914. The sources and markets of each of the various products have been discussed fully in former numbers of this bulletin. A considerable proportion of the sand and gravel sold during the past year was used by the Manila Railway Company in surfacing and ballasting the recently constructed southern division of the road. The values quoted for these commodities include no transportation costs. The unit costs of gravel varied from 60 centavos to 1.90 pesos, and of sand from 10 centavos to 1.25 pesos. No statistics were kept during the past year by the Bureau of Public Works, which is the largest individual consumer

[1] Dalburg, F. A., and Pratt, Wallace E., *Phil. Journ. Sci., Sec. A* (1914), **9**, 201; Pratt, Wallace E., *Min. Res. P. I. for 1913* (1914), 21.

[2] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

of sand, gravel, and stone; consequently the quantities and values of these materials as shown in the statistical table include an estimate for the consumption of the Bureau of Public Works based on the figures for previous years.

No coal was mined during the past year. The imports of coal amounted to 597,131 metric tons, valued at 3,499,590 pesos. The imports of coke amounted to 1,262 metric tons, valued at 15,642 pesos. By far the greater part of the coal came from Japan, while most of the coke was manufactured in Australia.

No cement was manufactured in the Philippines during 1914. The plant of the Rizal Cement Company at Binangonan, Rizal, is nearly completed, however, and will begin operation in 1915. This plant has a daily capacity of about 500 barrels. The imports of Portland cement during the calendar year 1914 amounted to 320,000 barrels, valued at 1,109,764 pesos. The imported cement came principally from Germany, Japan, and Hongkong. The largest exporter of cement to the Philippines was Germany, which supplied 25 per cent of the total quantity received. Japan and Hongkong each supplied nearly as much as Germany. Only a fraction of one per cent of the imports came from the United States.

There has been a lively demand for lime for use in sugar centrals, but the quality of the local supply has not met the requirements of the buyers. Lime has been imported to meet present needs, but it is probable that within a short time good lime in quantity sufficient to supply the market will be manufactured locally. The Philippine Lime and Products Company plans to burn lime at Binangonan, Rizal.

Imports of earthenware, stoneware, and china amounted to 1,926,578 pesos in 1914.

Imports of petroleum, naphtha, lubricating oil, fuel oil, and petroleum residuals amounted to 3,642,078 pesos in 1914.

COPPER DEPOSITS IN ZAMBALES PROVINCE

By V. E. Lednicky

The known existence of copper in commercial quantities in the Philippines has previously been limited to the Mancayan district, Mountain Province, and the recently reported discovery of an immense deposit in Zambales Province created some little excitement among local prospectors. Specimens of native copper were exhibited by the locators of the original claims, and the country was immediately staked by both Americans and Filipinos.

The copper deposits of Zambales Province are found in the Cabusilan Cordillera close to the eastern edge of Zambales and are included in the jurisdiction of the town of San Marcelino. Algao, about 6 kilometers to the west, is the nearest barrio, and Subic, the nearest sea port, is about 25 kilometers to the southeast. The claims covering the copper deposits are located around the headwaters of Pula River, a branch of the Aglao, which drains most of the surrounding country.

The country is very rugged, and the rapid streams have cut deep channels, which show the formation exceedingly well. Most of the country rock is a porphyritic andesite, which is very much broken up. Quartz veins are found filling the crevices, and several dikes cutting the andesite can be seen.

The region is well mineralized, and small veins of galena and sphalerite are found which are alleged to contain high gold and silver values. The copper occurs in small veinlets and masses, which fill fissures and cavities of the fractured andesite. The vein filling is siliceous, and the associated minerals are chalcopyrite, bornite, pyrite, malachite, and traces of azurite. Metallic copper is found disseminated through some of the rock in microscopic flakes and also is found in small sheets in veinlets and in cavities. Gold and silver is reported to have been found in paying quantities with the copper, but assays made by the Bureau of Science showed traces only.

Copper stain is found in a great number of places, and this seems to be the basis on which claims are staked. The description of the claims examined by the Bureau of Science is given in the order of their examinations.

The Panhandle claim.—The Panhandle claim is staked at the foot of Mount La Ta, at an altitude of 110 meters above the sea.

A small amount of work has been done on the discovery vein, but only enough to uncover it where it is crossed by a dry creek. The vein is in andesite and is 50 centimeters wide. It bears north 76° east with a dip of 69° to the south-southeast. It consists of a broken quartz with stringers of lead and zinc sulphides and pyrites. There is a green stain, but no copper minerals were seen. High values in gold and silver were claimed for this vein, but assays made in the Bureau of Science picked samples showed only 2 grams (4.66 pesos [1]) per metric ton.

The Blue Rock claim.—This claim is at an elevation of 230 meters above sea level on the side of Mount La Ta. A trench has been cut to a depth of 2 meters in the loose débris on the side of the mountain. It reveals only some fragments of blue quartz. The blue coloration of the quartz was supposed to be copper, but a rapid test with ammonia showed no copper.

The Water Falls.—Considerable work has been done along a copper-stained fracture plane in andesite. The mineralization is very narrow, and upon assay the ore showed neither gold nor silver.

The Horseshoe claim.—This claim has been staked on a 60-centimeter vertical vein of quartz striking north 30° east through andesite. Chalcopyrite and bornite are found in the small fractures in the quartz, but the percentage of copper is very low. One gram of gold per metric ton was obtained from samples taken across this vein. No work has been done here, although the vein appears to be the best prospect in the region.

The Copper King.—The Copper King claim is situated at the head of Pula River, which flows into the Aglao. It has an elevation of 280 meters above sea level. Considerable money has been spent here in stripping with an idea of showing the copper veins to better advantage and to develop the ore.

A face about 6 meters square has been exposed, which shows a network of small copper veins. The rock is a weathered andesite, and the veins are fillings of fractures and crevices. The copper minerals have been deposited by percolating water, and it is probable that the action continues at the present time, because the surface water appears to be charged with copper salts. The veinlets that are on the surface have been changed to carbonates, but beneath the original surface two small fractures about 3 centimeters wide have been found filled with crystallized metallic copper. Cavities slightly above the stream level are filled with a fine sand, which yields about 39 per cent of metallic copper, but these do not contain more than a few kilo-

[1] One peso Philippine currency equals 50 cents United States currency.

grams of material each. Taken as a whole it is probable that the rock in sight would not yield more than 1 per cent in copper. Only a trace of gold was found in two separate assays from this claim.

The Pioneer.—The Pioneer claim has been staked on a vein below the Copper King. It has a general north and south direction and dips 30° to the west. The vein is a soft quartz in andesite. It is 30 centimeters wide and can be traced for about 50 meters along the creek bank. It contains stringers of galena and sphalerite wtih occasional streaks of chalcopyrite. The locators have dug into the bank about 2 meters along this vein, and it shows signs of improving in width. Rich values of gold and silver were reported from here, but carefully taken samples across the face yielded only 2 grams of gold per metric ton. Selected specimens gave double this quantity. The zinc and lead ore is valueless unless great quantities are developed.

Hope claim.—This claim is situated about 300 meters north of the Copper King and is supposed to be on the same mineralized zone. Stringers of ore, containing lead, zinc, and copper, are encountered, and values of from 5 to 6 pesos have been shown by assays. An open trench 3 meters long has been cut into the side of the hill, but the solid formation has not been reached.

The Gunther claim.—The Gunther claim shows a very small stringer of galena and zinc in a soft seam at the edge of Lapo River. No development work has been done. The ore contains only a trace of gold.

An attempt was made to visit the Blackstone and one or two other claims, but the discovery posts could not be found by the locators. They are probably very similar to the claims already described.

Several mining engineers in private practice and several experienced prospectors who have examined the Zambales copper region have been disappointed in what they saw. The claims examined recently by the Bureau of Science promise little so far as the exploration work has gone. The division of mines, Bureau of Science, has also examined copper deposits in Pangasinan Province to the north of Zambales but in the same mountain chain. The examination of the Pangasinan deposits revealed nothing of value. In Tarlac Province, again, copper deposits similar to those in Zambales are known, so that the copper ores are widely disseminated in this cordillera even if they have not as yet been encountered in commercially valuable deposits.

NOTES ON THE MINERAL RESOURCES OF SURIGAO PROVINCE

By Wallace E. Pratt

Surigao Province has been a producer of gold for many years, but promises now to become more important in this respect through the operations of the recently organized Cansuran Placer Company. Attention has recently also been directed to Surigao's mineral resources by reason of the discovery by Mr. H. F. Cameron, engineer for the Department of Mindanao and Sulu, that a large area along the eastern coast of the province is covered with iron ore.

Gold mining in Surigao began in very remote times. The metal, detected first in the sands of the rivers and beaches, was traced almost at once to its original home in small quartz stringers and pockets in the andesite, which constitutes a large part of the land mass of the region. Although small, these quartz bodies appear to have been rich in gold at the surface, and at many places the ore has been taken out from open trenches and shallow holes over considerable distances.

One of the best known of the early prospectors in the Surigao gold region was a Frenchman referred to by the Filipinos as Don Maximillano. Apparently this man explored most of the known gold localities in Surigao early in the last century. He is said to have died at Surigao sixty-two years ago. It is stated that he worked first with the placer gold in the vicinity of the present holdings of the Cansuran Placer Company about 11 kilometers south of the town of Surigao. Later he prospected the gold-bearing quartz at Tinabingan, Placer, but ultimately he moved to the eastern margin of Lake Mainit, where he made his home and did most of his mining.

There is to-day little evidence of mining on the site of Don Maximillano's property at Mainit. Bricks are found in one locality at the edge of the foothills surrounding the lake, which the older residents believe to have been part of a furnace used by the Frenchman. Depressions which probably mark former shallow pits are found in the same neighborhood. A little gold is obtained by panning in an adjacent gully, and assays of a few pieces of ore encountered near one of the gold pits show fairly high gold values. There is no showing of ore in place, however, and it appears improbable that much mining was done here. The Frenchman is believed by the local people to have been rich, but he might easily have made enough from agriculture in this fertile region and from the sawmill, which he operated in clearing his land, to impress his simple neighbors.

A former mine which is famous in Surigao Province was located on a small island named Campiña, east of the Island of Masapelid in the jurisdiction of Placer. Gold was discovered on Campiña, the area of which is less than 1 hectare, about the year 1883, and mining was carried on assiduously for a period of two years, according to the presidente of the town of Placer. Mr. Maurice Goodman, a mining engineer, formerly in the Bureau of Science, visited Campiña and found rather extensive old workings, but although he took numerous samples, his assays showed only very low values in gold.[1] It is probable that the miners followed the usual rich stringers in andesite and exhausted the small deposit. It is estimated by some of the old miners that Campiña yielded 30,000 pesos [2] in gold.

C. A. Briggs, an American prospector who spent years in the Alaskan gold fields, is at present in control of the old mines at Tinabingan, Placer. Mr. Briggs has explored the lines of open trench and pits which mark a low ridge just back from the coast and has driven tunnels on several of the leads. He states that he has obtained high assays from various samples, but that samples over extended faces show less gold. Mr. Briggs is now devoting all his attention to exploring a new lead which reveals a width of about 2 meters of closely intersecting quartz stringers in silicified andesite and andesite breccia. A sample which he believes to be representative of the full width of this lead showed upon assay a value of 25 pesos per metric ton in gold. Although the mineralization at Tinabingan consists only of stringers and pockets, it is somewhat regular in that the strike of the leads at three different openings over the claims is constantly east-northeast.

William Ashburner, an American mining engineer who was prominent in his profession at the end of the last century, visited Surigao in 1883 and inspected much of the mining that was then in progress. He reported the presence of gold on Cansuran

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[1] *Min. Res. P. I. for 1908* (1909), 40.

[2] One peso Philippine currency equals 50 cents United States currency.

Creek near the town of Surigao in pockety stringers of quartz and calcite cutting slate. He also found angular gold in the placers at the mouth of Bigaa Creek, below Cansuran, which he believed to have come from the decomposition of the prevailing country rock, and at Tinabingan, Placer, he noted fragments of gold-bearing quartz but saw no veins.

According to the Spanish engineer Centeno, the most important gold district in Surigao is in the mountains of Canimon, Binutong, and Caumahat, which lie "a day's journey" (in reality about 11 kilometers) south of the town of Surigao. Around the base of these three mountains or, more properly, hills lies the gravel which is now being hydraulicked by the Cansuran Placer Company, and on the hills themselves lode claims are being prospected by the Surigao Mining Company. Centeno found veins in a talcose, serpentinoid slate, varying up to 10 centimeters in width. Some of the veins were quartzose, others were made up of calcite; in the calcite veins he noted chalcopyrite, galena, and zinc blends.

American prospectors were quickly attracted to this region following American occupation, and Messrs. C. A. Briggs, E. O. Parker, and R. W. McCullough obtained possession through mineral location and through the purchase of a Spanish grant to the placer property on Cansuran Creek and to the lode deposits on the hills examined by Centeno. The placer ground has been leased to the Cansuran Placer Company. The lode properties are controlled by the locators as the Surigao Mining Company.

In the openings which the Surigao Mining Company has made recently on Canimon and the adjacent hills ore has been encountered in andesite, in indurated shale and sandstone, and in a laminated, serpentinous rock which doubtless is the slate noted by Centeno. The gangue is quartz in the andesite and is usually dark-colored. In the shale and sandstone quartz and calcite both occur, and as recorded by the earlier observers form intersecting stringers through the rock. Visible gold can be detected in weathered portions of some of the ore, and angular, fairly coarse gold can be panned from the surface. The quartz in the andesite carries antimony in places, probably as the mineral jamesonite. All the fresh ore is pyritiferous. No veins of any size have been defined by the work so far, but large blocks of quartz and silicified andesite are encountered on the hillsides and in the streams. Some fairly high assay results have been obtained on samples taken by the men in charge of the work. There is a tendency toward a northeast or east-northeast alignment in the strike of the mineralization and in the structure of the bedded rocks, although in neither case is the strike constant.

Limestone is found associated with the indurated shale and sandstone, but in undeterminable relation. Away from the vicinity of the andesite the sedimentary rocks, especially the shales, are less disturbed and appear to form an extensive series. In addition to the rocks already noted there is a serpentine-schist at the base of the hills which forms the bedrock over a part of the placer area. Still another rock, not found in place, but scattered along the streams in large blocks, is a red, quartz-veined slate or indurated shale, parts of which assume the character of jasper.

The relations of the various rocks to each other are not clear. Probably the schist is the basal rock of the region, the sedimentaries having been deposited upon it and both rocks intruded later by the andesite. The formation of veins and the metamorphism and dislocation of the sedimentaries are probably due to the dynamism and mineralization accompanying or following the intrusion of the andesite.

The general character of the mineralization, the variety of rocks encountered, and the apparently nonuniform distribution of the gold values in this region are suggestive of conditions at the Tumbaga Mine, Mambulao, Camarines, where rich pockets of gold are found in calcite and quartz veinlets cutting andesite and indurated shale.

The gold-bearing gravel now being exploited by the Cansuran Mining Company in the vicinity of these vein-deposits in Surigao has proved since hydraulicking began to contain exceedingly large bowlders. It is not confined in its distribution to the present river beds, but covers the intervening ridges and slopes as well. It is rarely more than 5 meters in thickness, and in places the underlying bedrock is exposed at the surface. The large bowlders are partly rounded with occasional angles, while the small stones are worn smooth. A striking feature of the placer area is the extent of the old workings which are to be inferred from the remains of ditches, shafts, and rock sluices encountered everywhere.

Most of the gold is rounded and fairly coarse, varying from the size of rice grains up to rare nuggets of 30 grams' weight. A small proportion of sharp, angular gold, somewhat darker in color than the rounded gold and usually in smaller particles, is also obtained. Some specimens of both classes of gold inclose quartz. The gold in the nuggets is spongy or porous, and the larger nuggets may be broken readily. Melted into bullion the gold retains its brittle character, and the bars crumble or break if they are roughly handled. The average bullion has a fineness of about 770 gold.

Different observers have speculated as to the probable source of the gold in the Cansuran placers. It has been suggested that the rounded gold nuggets are from a distant source and have been carried to their present position by flowing water, while the sharp, angular gold came from the veins in the hills adjacent to Cansuran Creek. The fact that the gravel is distributed over valley and ridge alike has been cited as evidence of the former existence of a great river, the bed of which was at a level corresponding to the present ridges and was flanked on either side by a strip of gravel wash about 1 kilometer wide. The rounded gold presumably was brought from a distance and deposited with the gravel. It is further supposed that subsequent differential elevation of the land mass, perhaps coincident with the intrusion of the andesites, interfered with the flow of the former river and left the gravels to be worked over by the modern drainage system.

It is apparent from the distribution of the gravel and the size of the bowlders that the assumed former river must have been of great volume and consequently probably of great length. The land mass of Mindanao is generally believed to have been smaller formerly than it is at present, and it is difficult satisfactorily to place the course of such an ancient river. Moreover the character of the gravel—large bowlders in a clay matrix—is not that of old river bars. According to the tests, also, neither the gold nor the gravel is regularly distributed over a large continuous area such as the flood plains of a large river would form, but is confined to detached sections in a general alluvial region. There are no conspicuous evidences of a typical terrace structure in the gravels, but the wash follows closely the present topography, covering the lower ridges, the slopes, and the valley floors alike.

Consequently the correctness of the theory as outlined is questionable. From its character and distribution the gravel can be more satisfactorily accounted for as talus and piedmont deposits from the adjacent mountains, which, as has been shown, are gold-bearing. The rounding of some of the gold and of the gravel might have been accomplished by the abrasion incident to slides and other processes of degradation on the local mountain slopes. The stringers and small veins in these mountains are rich in free gold and might well have yielded nuggets of considerable size. The sharp, fine gold found in the placers may come from the numerous veins in the schist which forms the bedrock over the placer area itself. The fact that there is antimony in the gold-bearing quartz of the mountains and that alloyed antimony might be responsible for the brittle character of the nuggets in the placer is likewise suggestive that the nuggets came from adjacent lodes.

The iron-ore deposits of Surigao Province have just been surveyed by the division of mines of the Bureau of Science, and while it is not possible to draw conclusions until the results of a large number of analyses can be obtained, it appears that the findings of Mr. Cameron as reported by him originally are verified. The deposit appears to be similar in character to the Mayari iron ores which are being exploited in the vicinity of Nipe Bay, Cuba. The ore is a variety of laterite, a decomposition product from the weathering, under tropical conditions, of subsiliceous igneous rocks, and consists of hydrated oxides of iron in the form of clay and small concretions. The parent rock in Surigao appears to be a peridotite largely altered to serpentine. It occurs along the eastern coast of the province from the barrio of Capandan, Guigaquit, to the barrio of Adlay, Cantilan, a distance of 20 kilometers, and with its cover of iron ore extends inland over a belt ranging up to about 6 kilometers in width. Flanking this area are sedimentary rocks, tuff-sandstones, limestones, and shale. The vegetation, which is very sparse and of a peculiar character near the coast, gradually becomes more abundant and normal in character toward the interior.

The iron-ore deposit is unusual in that it covers a thoroughly dissected country made up of fairly sharp ridges and precipitous valleys. Other known iron-ore deposits of this class occur on nearly level plains or plateaus. Surigao is also a region of heavy rainfall (more than 3 meters annual) with practically no dry season, whereas one of the theories brought forward to explain the origin of ferruginous laterites involves a condition of alternating and marked seasons of drought and rainfall. According to the first analyses made on samples taken by Mr. Cameron the chemical character of the material is such as to make it a valuable iron ore. A large number of samples taken so as to reveal the character of the deposit as a whole are now being analyzed. The following tables show some of the results of analysis:

TABLE I.—*Analyses of Surigao iron ore.*[a]

Constituent.	Sample. 1 [b]	2 [b]	3 [b]
Hygroscopic water		13.50	
Combined water		6.60	
Ferric oxide (FeO)		66.80	
Ferrous oxide (FeO)		0.36	
Alumina (AlO)		10.56	
Silica (SiO)		1.04	
Chromium oxide (CrO)		1.15	
Sulphur (S)		trace	
Phosphorous (P)		trace	
Nickel and cobalt		none	
Total		100.01	
Total iron (Fe) in dry ore	54.15	54.29	51.92
Total iron (Fe) in sintered ore		58.77	

[a] Analyses by F. Peña, chemist, Bureau of Science.
[b] Samples taken by Mr. Cameron.

TABLE II.—*Analyses of iron ores from Surigao Province.*[a]

Description of samples.	Loss on ignition in dried ore (110° C.).	Iron (Fe) in dried ore (110° C.).	Iron (Fe) in sintered ore.
Shaft: Interior limit of deposit, south of Taganito	14.76	53.40	62.65
Drill hole 1:			
Surface to 3 meters; on coast near middle of deposit	12.50	47.30	54.06
3 to 6 meters	12.70	42.56	48.75
6 to 9 meters	12.20	29.59	33.70
Drill hole 12:			
Surface to 3 meters; south part of ore deposit near Dahikan Bay	12.50	47.30	54.05
3 to 6 meters	11.08	55.75	62.70
6 to 9 meters	11.80	42.56	48.26
9 to 12 meters	11.15	29.68	33.41
Drill hole 17:			
Surface to 3 meters; south part of deposit near Dahikan Bay	13.05	45.64	52.49
3 to 6 meters	11.04	37.16	41.78
6 to 9 meters	10.57	48.01	53.68
9 to 12 meters; south part of deposit near Dahikan Bay	11.93	54.86	62.29
Drill hole 36: Surface; south part of ore deposit near Dahikan Bay	14.10	46.79	54.46
Drill hole 72:			
Surface to 3 meters; north part of deposit near Taganito	14.16	45.64	53.18
3 to 6 meters	12.41	45.63	52.10
6 to 9 meters	13.60	42.28	48.93
Drill hole 79:			
Surface; north part of deposit near Taganito	15.34	47.39	55.98
Surface to 3 meters	14.00	48.16	56.00
6 to 9 meters	13.57	51.89	59.46
Average	12.76	45.32	51.99

[a] Analyses by T. Dar Juan, A. S. Arguelles, and F. Peña, chemists, Bureau of Science.

The term sintered ore, as used in the foregoing tables, implies freedom from all moisture both hygroscopic and combined. The samples were obtained by drilling through the iron-ore mantle to bedrock, each sample representing a length of 3 meters of drill hole. Nearly 100 holes were drilled at the corners of regular squares, so that there would be no unconscious selection of favorable or unfavorable drilling sites. Proceeding in this manner, it developed that a considerable proportion of the drill-hole sites fell on ground from which the ore had been entirely removed, so that the underlying bedrock was exposed. At other places the depth of ore varied from 1 to 18 meters. The analyses show that some of the ore contains too little iron to be valuable. The sintered or nodulized ore mined in the Mayari district in Cuba, while it retains, or reabsorbs, 3.5 per cent of moisture, averages 55 to 56 per cent metallic iron [2] for the year's operation. Apparently values as high as this average could not be obtained uniformly in Surigao. It follows that parts of the iron-ore region will be of no value because of the shallowness of the ore mantle and that all the ore is not of high enough quality to be of commercial value. Before more definite statements can be made, the results of a greater number of analyses must be obtained, and the data relative to the depth and position of the various drill holes must be correlated.

[2] Kemp, James F., *Bull Am. Inst. Min. Eng.* (1915), **98**, 131.

THE LUBANG GOLD DISTRICT IN SOUTHERN BENGUET

By V. E. Lednicky

The steady production of a small amount of gold during the past few months has attracted attention to the Lubang district in Benguet Province. This district is distinctly separate from the Baguio region and gives enough promise of becoming a producer of gold to merit description.

Gold was first found in the Lubang district by the Igorots, who panned along the creeks and also worked on one or two small veins. Probably this work had begun at a very early date. Their workings and small stone mills used to grind the ores can still be seen.

The first Americans to go into the district were ex-soldiers with mining experience, and some of the original locators are still there. They have kept up their prospecting and development work until they are well acquainted with the more prominent veins of the country.

The following notes were made during a visit of a few days to the workings on the located claims.

The Lubang district is situated on Lubang River, in the southern end of Benguet Province, about 40 kilometers from the nearest railroad. Lubang River is a branch of the Tubuoy, which flows into Agno River about 50 kilometers from its mouth. Tubuoy River, with its several branches, drains all of the gold-bearing region of southern Benguet. About 5 kilometers above Binalonan, Pangasinan Province, it flows out of the mountainous country through a steep-walled cañon on to a flat, sandy plain, across which it meanders for a distance of about 20 kilometers to its mouth. The floor of the cañon is covered with coarse gravel, into which the small, swift-flowing stream sinks at intervals, leaving stretches of dry river bed. During the dry season the volume of water is small, but the appearance of the cañon floor indicates an abundance of water during the rainy season. The lower part of the cañon has very steep walls, varying in height from 15 to 30 meters. As you go upstream the walls gradually diminish in height until Lubang River is reached. This river also has very steep walls.

The mines of the Lubang district may be reached from Magaldan, the end of the railroad, by means of automobile to Binalonan and on horseback from there to Lubang. Owing to the numerous trails it is advisable to take a guide from Binalonan, who can also act as a carrier.

The trail across the plain from Binalonan and up Lubang River cañon is passable for carabao carts, and the trip can be made without difficulty. The carts haul about 200 kilograms at a load and receive 5 pesos [1] per load from Binalonan. During the dry season regular trips are made, but in the wet season the trips are necessarily dependent upon the weather. The freight rate from Magaldan to Binalonan is 0.5 centavo per kilogram.

The country around the mines is almost bare of timber suitable for mining purposes. The local supply of firewood is insufficient for boiler fuel. Short timbers for stoping can be obtained at about 50 centavos each, but they do not serve for drift sets or lumber. A species of pine tree grows on the bars and low banks of Tubuoy River, attaining a maximum diameter of 35 centimeters; they are tall enough for three upright drift timbers. This class of wood has never been tried in the mines at Lubang, but the Bureau of Forestry recommends it as a very durable material.

A considerable growth of bamboo around the Mentzer camp would furnish building material for laborers' houses, and there is an abundance of grass to cover the roofs. Grass for forage is plentiful during the rainy season, and would be an asset in case more animals were used in hauling supplies.

The rainy season begins in May and lasts through October; during these months it is rather difficult to use the cañon road, and it is sometimes necessary to follow the mountain trail on the top of the ridges. During the rainy season there is an abundance of water for mining purposes. A fall of 100 meters could be utilized for the development of water power without an excessive expenditure. At present a supply of water sufficient for a 10-stamp battery is available.

In outline, the geology of the district is as follows: Two distinct formations are present, the Tertiary sedimentaries and the older extrusives and plutonic rocks. The district may be said to be on the southern edge of the extrusive in Benguet Province, described by Eveland [2] and Smith. [3] The formation downstream

[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

[2] *Phil. Journ. Sci., Sec. A* (1907), **4**, 207.

[3] *Ibid.* (1911), **6**, 429.

from the Mentzer camp is mostly conglomerate of considerable thickness, capped in places with a comparatively thin layer of limestone. The conglomerate contains igneous and sedimentary rocks varying from pebbles the size of peas to bowlders 1 meter or more in diameter. The overlying limestone is very hard and pure enough to burn for lime, although it contains some quartz and is somewhat colored by iron stains. The igneous rocks, which probably represent the basal formation in the district, are predominantly holocrystalline, but andesites and porphyries are found in various places.

The economic geology of the district cannot be well determined with the development work that has been done, since none of the work extends beyond the oxidized zone. In general, the country rock of the district is diorite, but small intrusive dikes of andesite and porphyry are common. The diorite has suffered considerable disturbance, and the veins are fillings of fissures produced by movement. The fissures occur along nearly parallel lines with a general east-west direction. The irregular, shattered zones between the fissure planes have been altered, and broken quartz fills the cracks and seams. The values in the fissures are not uniform, but appear to be confined to irregular quartz stringers throughout the vein material of broken quartz and clay. Rich pockets of visible gold are found, but they are not very large. Several wide veins of quartz can be traced along the ridges, and some of them show good values on assay. It is possible that more uniform values could be obtained from them than from the softer veins that have been developed. All of the development work indicates that sulphides are to be expected with depth. Free-milling ores are not to be depended upon, therefore, for large operation.

One or two small companies have attempted to exploit the district, but lack of sufficient capital has kept them from putting the mines on a paying basis. Two small mills are operating. One is under the charge of George Mentzer, and the other is under J. H. McMichael.

The claims of the Lubang district may be divided into three groups: the lower, the central, and the upper. The majority of these are included in the lower group under the supervision of Mr. Mentzer. He has developed several veins on the property and has completed about 185 meters of tunnel. Most of the veins have a strike of about north 80° east, dip 55° south, and can be traced to the ridges on the opposite side of Tubuoy River. They vary in width from 60 centimeters to 2 meters and have a very great range in value. No work is done in ground that does not pan free gold, but the pannings are not always an indicator of the actual assay value. One vein, 60 centimeters wide, known as the sulphide vein, pans some free gold but assays a great deal more. It has been opened on two levels, 30 meters apart, and shows no sign of pinching out. At present most of the ore for the mill is being stoped on the Independence claim. This ore is low grade, but shows richer sulphide values with depth.

The central group of claims belongs to Mr. Horn. He has done development work on all the claims and has some exceptional values. A bull-quartz vein 2 meters wide, which outcrops along a ridge for a hundred meters or more, is perhaps the best prospect on these claims. The values are not high on the surface, but tunnels into the ridge have struck rich ore beneath the surface.

On the upper group of claims Mr. McMichael has erected a small mill and has driven a total length of about 500 meters of tunnel on a half dozen veins. Some rich ore has been encountered, but the oxidized zone is shallow and the work has not been carried into the sulphides. Some coarse, visible gold is obtained, but most of the free gold is very fine. At present Mr. McMichael is working in a new place where values seem to be very generally distributed. The ground is very much broken, and as yet no definite vein has been found, but good leads are being followed. In one of the tunnels a sample of red clay taken by the Bureau of Science showed over 1 per cent of mercury. This is probably the source of the cinnabar that can be panned along Tubuoy River. One vein recently opened by Mr. McMichael is very rich in galena and sphalerite. It contains some silver, but not enough to make it valuable.

The Mentzer mill, situated at the lower end of the district, is a 3-stamp prospecting mill made by the Mine & Smelters' Supply Company of Denver, Colorado. The stamp product is amalgamated, but concentration over a Challenge table has been attempted. The ore is sorted at the mine, and only the small material is sent to the mill. Sledges drawn by bulls are used for transporting the ore. A small tramway or chute would undoubtedly be cheaper, as the sledge is very slow and rather expensive. The ore from the sledges is dumped above the mill and shoveled down to the stamps. It is fed into the battery by hand from a trough at a level with the top of the mortar. The three 250-pound stamps are not heavy enough to crush hard rock, and only pieces of quartz 2 centimeters in diameter or less can be taken. When crushing soft ore, an output of 1.5 tons per stamp per twelve hours is obtained through a 30-mesh screen. Mercury is fed into the mortar, and a large percentage of the recoverable value is obtained by inside amalgamation. The discharge passes over a 2- by 8-foot amalgamation table with two silvered copper plates. A triple mercury trap at the end of the table catches most of the excess mercury and gold that escapes the table. About 80 per cent of the free gold in the screen product is amalgamated on the first 60 centimeters of the upper plate, and the other 20 per cent is caught below or is lost with the slimes. No amalgamation tests have been made to ascertain the exact recovery, but probably the loss of free gold is small.

The power is furnished by a 3-horsepower Hornsby oil engine, which uses about 19 liters of kerosene every twelve hours. The engine has given excellent service for over one year and in that time has not needed repairing. The mill is only run twelve hours per day and requires a crew of one American and two Filipinos. An attempt will be made to run it the full twenty-four hours in the future.

An attempt to concentrate the tailings on a Challenge table was tried for some time, but the concentrates never proved rich enough to pay for smelting. Mr. Mentzer tried mixing the concentrates with clay and making balls, which he roasted on a wood fire. The method was successful as far as oxidizing the sulphides was concerned, but he had difficulty in milling the roasted product. The clay blinded the screens, and the ashes from the fire fouled the plates so that they were very hard to dress for several days afterwards. Owing to this difficulty and also to the extra work entailed, the concentrator was abandoned; the tailings go directly through the launder to the creek. It is suggested that it might be profitable to bank the tailings and keep them for future cyaniding.

The mill on the upper group of claims is not working at present, but will be run continuously as soon as the rainy season starts. It consists of a 3.5-foot Huntington mill of the improved type, bolted securely to a foundation of heavy timbers. It is equipped with 60-mesh punched slot screens, and the crushed product passes over silvered copper plates and through a launder on to a 3- by 8-foot bumping table made after the Gilpin County Colorado table. This table was built in Manila and seems to give good results, but as yet nothing has been done with the concentrates. Amalgamation inside the Huntington mill catches almost all the free gold.

This mill is run at 90 revolutions per minute and gives an output of 4 to 5 tons per twenty-four hours through a 60-mesh screen if fed with an ore not coarser than 2.5 centimeters maximum diameter. A 12-horsepower Olds oil engine has been used for power, but milling was discontinued because of the excessive fuel cost. The kerosene consumption was 28 liters in twelve hours, and the estimated cost was about 17 centavos per liter. It was decided to store ore during the dry season and to run the mill only during the rainy season when water power could be obtained.

A 5-meter overshot water wheel was built this year and was operated about thirty days before the rains stopped. It is built entirely of wood and seems to give excellent results. The power is transmitted by a belt from a 2-meter fixed pulley directly to the Huntington mill. The installation of a small primary crusher for which water power is available would undoubtedly prove economical.

The Lubang district will probably some day be a fair producer of gold. The values are there, but more development work, which will entail the expenditure of several thousand pesos, must be done before a mill could be built.

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Fig. 1. Igorot mining in Suyoc.

Fig. 2. Igorot milling in Suyoc.

PLATE I.

GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF THE INTERIOR
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1915

ISSUED BY THE DIVISION OF MINES
BUREAU OF SCIENCE

MANILA
BUREAU OF PRINTING
1916

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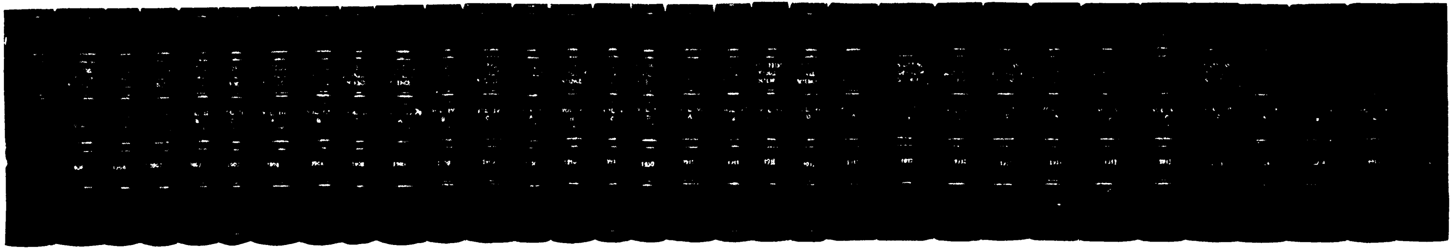

Volume I and botanical supplement (1906); volumes II to IV, sections A, B, and C (1907–1909); volumes V to IX, sections A, B, C, and D (1910–1914).

THE PHILIPPINE JOURNAL OF SCIENCE AND OTHER PUBLICATIONS

The Bureau of Government Laboratories (now the Bureau of Science) was established July 1, 1901, by Act No. 156 of the Philippine Commission; actual chemical and biological work was begun on September 25 of the same year with 6 employees in a rented house on Calle Iris, Manila. The photographic collection, which developed rapidly and now includes some 15,000 negatives, was begun on November 16, 1901. Entomological investigations and the making of a collection of insects began on December 9, 1902. The serum laboratory and the grounds at San Lazaro were transferred to the Bureau from the Board of Health on January 1, 1903. The section of botany, which had been organized in the Bureau of Agriculture, and the nucleus of the herbarium were added on July 1, 1903. The collectors of natural history specimens were transferred from the Ethnological Survey to the Bureau of Government Laboratories on November 16, 1904. The Mining Bureau became an integral part of the Bureau of Science on November 1, 1905, and the Ethnological Survey, formerly the Bureau of Non-Christian Tribes, later a part of the Bureau of Education, was transferred to the Bureau of Science as the division of ethnology on November 1, 1906.

The present laboratory building of the Bureau of Science was first occupied in 1904, and the work was enlarged by the appointment of an engineering force and by the operation of steam and electric machinery. The present power plant supplies electric current, steam, gas, etc., to the Bureau of Science, the Philippine General Hospital, and the College of Medicine and Surgery. A substantial wing was added to the Bureau of Science building in 1911.

The purchase of books for the library began soon after the organization of the Bureau, and this adjunct of the scientific work grew rapidly, necessitating the gradual enlargement of the force and the organization of the library staff. The original plan contemplated an expenditure spread over a period of six years for books and sets of periodicals on chemistry, geology, zoölogy, bacteriology, pathology, physiology, and related sciences. The books purchased, together with the thousands of pesos' worth of publications which were received gratis, formed the nucleus of the scientific library of the entire Government. The publications received by gift and the continuations of sets purchased from current appropriations have been bound. These, together with the books and periodicals which have been provided by the University of the Philippines, have been placed in the library.

The Bureau of Government Laboratories and the Mining Bureau issued publications in pamphlet form which were distributed without charge. In 1906 the Bureau of Science ceased publishing its material in the form of bulletins and started The Philippine Journal of Science. A subscription price was charged to prevent waste and miscellaneous distribution and to effect economy, but the Journal has been sent to the leading scientific institutions in exchange for their publications, which have become valuable additions to the division of science of the Philippine Library.

The first volume of the Philippine Journal of Science consisted of 10 numbers with 1,085 pages and a botanical supplement of 5 numbers with 393 pages. Because of the large amount and great variety of matter presented for publication it became desirable to divide the Journal and beginning with volume II three sections were published. Section A contained articles on geology and mining, chemistry, anthropology, and zoölogy; section B was devoted entirely to medicine; and section C took the place of the botanical supplement. The contributions to section A became so numerous that with volume V this section was divided, and since then section A has been devoted to chemistry and geology and the related industries, while a new section to accommodate articles on ethnology and zoölogy was established, known as section D.

The Philippine Journal of Science and other current publications of the Bureau of Science, as well as the publications of the former Bureau of Government Laboratories, Mining Bureau, and Ethnological Survey are listed on the following pages.

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Elateridæ des îles Philippines. *Ed. Fleutiaux.*
Catalogue des Psélaphides (Coleopteres) des îles Philippines. *A. Raffray.*
The Igorots of Lepanto. *James A. Robertson.*
Description of a new species of Prionochilus from the highlands of Luzon. *Richard C. McGregor.*
Nitidulidæ des Philippines recoltés par C. F. Baker. *A. Grouvelle.*

PUBLICATIONS FOR SALE BY THE BUREAU OF SCIENCE, MANILA, PHILIPPINE ISLANDS

The following are the titles of a few separates from The Philippine Journal of Science and of monographs, manuals, and longer ethnological and other papers published by the Bureau of Science. These books do not constitute a series of publications, and are listed only for convenience.

THE COCONUT PALM IN THE PHILIPPINE ISLANDS. By PAUL C. FREER, E. B. COPELAND, H. S. WALKER, and C. S. BANKS.
Separate from The Philippine Journal of Science (1906), 1, Nos. 1, 2, and 3; 149 pages, 30 plates.
Order No. 37. Paper, $1 United States currency, postpaid.

THE SUGAR INDUSTRY IN THE ISLAND OF NEGROS. By HERBERT S. WALKER.
Bureau of Science Publications [No. 3]; 145 pages, 10 plates, 1 map.
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A FLORA OF MANILA. By ELMER D. MERRILL.
Bureau of Science Publications, No. 5; 490 pages.
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INDO-MALAYAN WOODS. By FRED W. FOXWORTHY.
The Philippine Journal of Science, Sec. C (1909), 4, No. 4; 182 pages, 9 photographic plates.
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PHILIPPINE HATS. By C. B. ROBINSON.
Separate from The Philippine Journal of Science, Sec. C (1911), 6, No. 2.
Order No. 415. Paper, $0.50 United States currency, postpaid.

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The Philippine Journal of Science, Sec. A (1914), 9, Nos. 5 and 6. Bound under one cover.
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A MANUAL OF PHILIPPINE BIRDS. By RICHARD C. MCGREGOR.
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Bureau of Science Publications, No. 1; 78 pages.
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The Philippine Journal of Science, Sec. D (1912), 7, No. 1; 64 pages.
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REPORT OF THE INTERNATIONAL PLAGUE CONFERENCE. Held at Mukden, April, 1911, under the auspices of the Chinese Government.
Edited by ERICH MARTINI, G. F. PETRIE, ARTHUR STANLEY, and RICHARD P. STRONG.
483 pages, 18 plates (2 colored, 4 half-tones, 12 charts and maps).
Order No. 416. Paper, $2.50; cloth, $3.50; United States currency, postpaid.

NEGRITOS OF ZAMBALES. By WILLIAM ALLAN REED.
Ethnological Survey Publications. Volume II, Part I; 83 pages, 62 plates.
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THE NABALOI DIALECT. By OTTO SCHEERER.
Ethnological Survey Publications. Volume II, Part II; 65 pages, 29 plates.

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Division of Ethnology Publications. Volume IV, Part I; 107 pages, 16 plates, 5 diagrams.

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Division of Ethnology Publications. Volume V, Part I.

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A VOCABULARY OF THE IGOROT LANGUAGE AS SPOKEN BY THE BONTOK IGOROTS. By WALTER CLAYTON CLAPP.

Division of Ethnology Publications. Volume V, Part III; 89 pages.

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Order No. 421. Paper, $0.75 United States currency, postpaid.

A VOCABULARY AND PHRASE BOOK OF THE LANAO MORO DIALECT. By CHARLES W. ELLIOTT.

Division of Ethnology Publications. Volume V, Part V; 28 pages.

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PUBLICATIONS OF THE FORMER BUREAU OF GOVERNMETN LABORATORIES, ETHNOLOGICAL SURVEY, PHILIPPINE MUSEUM, AND BUREAU OF MINES, NOW INCORPORATED IN THE BUREAU OF SCIENCE

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Nos. 1 to *20* are out of print.

21. *No. 21, 1904, Biological Laboratory.*—Some Questions Relating to the Virulence of Micro-organisms with Particular Reference to Their Immunizing Powers. By Richard P. Strong, M. D.

Nos. 22 and *23* are out of print.

24. *No. 24, 1904, Biological Laboratory.*—Glanders: Its Diagnosis and Prevention Together with a Report on Two Cases of Human Glanders Occurring in Manila and Some Notes on the Bacteriology and Polymorphism of Bacterium mallei. By William B. Wherry, M. D.

25. *No. 25, 1904.*—I. Birds from the Islands of Romblon, Sibuyan, and Cresta de Gallo. II. Further Notes on Birds from Ticao, Cuyo, Culion, Calayan, Lubang, and Luzon. By Richard C. McGregor. (*For first four bulletins of the ornithological series, see Ornithology on page 9.*)

26. *No. 26, 1904, Biological Laboratory.*—The Clinical and Pathological Significance of Balantidium coli. By Richard P. Strong, M. D.

27. *No. 27, 1905.*—A Review of the Identifications of the Species Described in Blanco's Flora de Filipinas. By Elmer D. Merrill, Botanist.

Nos. 28, 29, and *30* are out of print.

31. *No. 31, 1905, Biological Laboratory.*—I. Notes on a Case of Hæmatochyluria Together with Some Observations on the Morphology of the Embryo Nematode Filaria nocturna. By William B. Wherry, M. D., and John R. McDill, M. D. II. A Search into the Nitrate and Nitrite Content of Witte's "Peptone" with Special Reference to Its Influence on the Demonstration of the Indol and Cholera-red Reactions. By William B. Wherry, M. D.

Nos. 32, 33, and *34* are out of print.

35. *No. 35, 1905.*—I. New or Noteworthy Philippine Plants, IV. II. Notes on Cuming's Philippine Plants in the Herbarium of the Bureau of Government Laboratories. By Elmer D. Merrill. III. Notes on Philippine Gramineæ. By E. Hackel. IV. Scitimineæ Philippinenses. By H. N. Ridley. V. Philippine Acanthaceæ. By C. B. Clarke.

36. *No. 36, 1905.*—A Hand-List of the Birds of the Philippine Islands. By Richard C. McGregor and Dean C. Worcester.

The First, Second, Third, and Fourth Annual Reports of the Superintendent of the Bureau of Government Laboratories are out of print.

The series of Bulletins of the Bureau of Government Laboratories ceased with No. 36. The Annual Reports of the Superintendent of the Bureau of Government Laboratories are continued as Annual Reports of the Director of the Bureau of Science. (*See page 10.*)

All of the publications in the above list were issued for free distribution. A few copies of the titles given are still obtainable.

GEOLOGY AND MINING

(Publications of the former Mining Bureau, now Division of Mines, Bureau of Science)

45. *1890.*—Descripción física, geológica y minera en bosquejo de la Isla de Panay por D. Enrique Abella y Casariego, Inspector General de Minas del Archipiélago.

1890.—Memoria descriptiva de los manantiales minero-medicinales de la Isla de Luzón, estudiados por la comisión compuesta de los Señores D. José Centeno, Ingeniero de Minas y Vocal Presidente, D. Anacleto del Rosario y Sales, Vocal Farmacéutico, y D. José de Vera y Gómez, Vocal Médico. *Out of print.*

1893.—Estudio descriptado de algunos manantiales minerales de Filipinas ejecutivo por la comisión formada por D. Enrique Abella y Casariego, Inspector General de Minas, D. José de Vera y Gómez, Médico, y D. Anacleto del Rosario y Sales, Farmacéutico; precedido de un prólogo escrito por el Excmo. Sr. D. Angel de Avilés, Director General de Administración Civil. *Out of print.*

1893.—Terremotos experimentados en la Isla de Luzón durante los meses de Marzo y Abril de 1892, especialmente desastrosos en Pangasinán, Unión y Benguet. Estudio ejecutado por D. Enrique Abella y Casariego, Inspector General de Minas del Archipiélago. *Out of print.*

49. *1901.*—The Coal Measures of the Philippines. Charles H. Burritt.

50. *1902.*—Abstract of the Mining Laws (in force in the Philippines, 1902). Charles H. Burritt.

51. *1902, Bulletin No. 1.*—Platinum and Associated Rare Metals in Placer Formations. H. D. McCaskey, B. S.
1903.—Report of the Chief of the Mining Bureau of the Philippine Islands. Charles H. Burritt. *Out of print.*
53. *1903, Bulletin No. 2.*—Complete List of Spanish Mining Claims Recorded in the Mining Bureau. Charles H. Burritt.
1903, Bulletin No. 3.—Report on a Geological Reconnoissance of the Iron Region of Angat, Bulacan. H. D. McCaskey, B. S. *Out of print.*
55. *1904.*—Fifth Annual Report of the Mining Bureau. H. D. McCaskey.
56. *1905.*—Sixth Annual Report of the Chief of the Mining Bureau. H. D. McCaskey.
57. *1905.—Bulletin No. 4.*—A preliminary Reconnoissance of the Mancayan-Suyoc Mineral Region, Lepanto, P. I. A. J. Eveland, geologist.
58. *1905, Bulletin No. 5.*—The Coal Deposits of Batan Islands. Warren D. Smith, B. S., M. A., geologist.

The Bulletins of the Mining Bureau were issued for free distribution. The series was discontinued when that Bureau became the Division of Mines of the Bureau of Science.

ETHNOLOGY

(Publications of the former Ethnological Survey, now Division of Ethnology, Bureau of Science)

All prices are in United States currency, and include postage

401. *Vol. I, 1905.*—The Bontoc Igorot. By Albert Ernest Jenks. Paper, $1; half morocco, $1.50. *Out of print.*
402. *Vol. II, Part 1, 1904.*—Negritos of Zambales. By William Allan Reed. Paper, $0.25; half morocco, $0.75.
403. *Vol. II. Part 2 and Part 3, 1905.*—The Nabaloi Dialect. By Otto Scheerer. The Bataks of Palawan. By Edward Y. Miller.
403a. Vol. II, Parts I, II, and III, in one volume, half morocco, $1.50.
404. *Vol. III, 1904.*—Relaciones Agustinianas de las razas del Norte de Luzon. By Perez. *Out of print.*
405. *Vol. IV, Part 1, 1905.*—Studies in Moro History, Law, and Religion. By Najeeb M. Saleeby. Paper, $0.25; half morocco, $0.75.

The publications of the Ethnological Survey were issued for free distribution, but are now for sale only. The series is continued as Publications of the Division of Ethnology, Bureau of Science.

ORNITHOLOGY

(Publications of the former Philippine Museum, now Section of Ornithology and Taxidermy, Bureau of Science)

Bulletins *Nos. 1* to *4* are out of print.

The Section of Ornithology of the Bureau of Science was formerly under the administration of the Bureau of Non-Christian Tribes (later the Ethnological Survey), and the four Bulletins listed above were published during that period. With the transfer of the ornithological work and collections to the Bureau of Government Laboratories in 1904, papers on ornithology were issued as Bulletins of that Bureau. See numbers 25, 34, and 36.

The present Philippine museum is a part of the Division of Ethnology, Bureau of Science, and has no separate organization. It is concerned mainly with the collection and display of ethnological specimens.

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PUBLICATIONS

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Order No.

102. *No. 1, 1909.*—A Check-list of Philippine Fishes. By David Starr Jordan and Robert Earl Richardson. Paper, $0.75.
103. *No. 2, 1909.*—A Manual of Philippine Birds. By Richard C. McGregor, Parts I and II. Paper, $4 for the two parts.
412. [*No. 3*] *1910.*—The Sugar Industry in the Island of Negros. By Herbert S. Walker. Paper, $1.25.
413. [*No. 4*] *1911.*—A Manual of Philippine Silk Culture. By Charles S. Banks. Paper, $0.75.
419. *No. 5, 1912.*—A Flora of Manila. By Elmer D. Merrill. Paper, $2.50.

SEPARATES

Separates from The Philippine Journal of Science are regularly printed for the use of the authors. Extra copies of the following were printed and are for sale by the Bureau of Science:

37. On the Coconut Palm in the Philippine Islands. From The Philippine Journal of Science (1906), 1, Nos. 1, 2, and 3. Paper, $1.
411. Indo-Malayan Woods. By Fred W. Foxworthy. Phil. Journ. Sci., Sec. C (1909), 4, No. 4. Paper, $0.50.
415. Philippine Hats. By C. B. Robinson. From Phil. Journ. Sci., Sec. C (1911), 6, No. 2. Paper, $0.50.
418. A List of the Mammals of the Philippine Islands, Exclusive of the Cetacea. By N. Hollister. Phil. Journ. Sci., Sec. D (1912), 7, No. 1. Paper, $0.50.
420. Philippinische Rüsselkäfer. Von K. M. Heller. Phil. Journ. Sci., Sec. D (1912), 7, Nos. 5 and 6 under one cover. Paper, $1.

PRICE LISTS AND FOLDERS

101. Price and exchange list of Philippine bird skins in the collection of the Bureau of Science, Manila, P. I. (Effective January 1, 1908.) *Out of print. Cancelled. See No. 104.*
104. Price and exchange list of Philippine bird skins in the collection of the Bureau of Science, Manila, P. I. (Effective 1911.) *Free.*
105. Price and exchange list of Philippine insects in the collection of the Bureau of Science, Manila, P. I. (Effective January 1, 1911.) *Free.*
417. Price-list of photographs for sale by the Bureau of Science. [Issued February 16, 1912.] *Free.*
423. Schedule of charges for work done by the Bureau of Science. [Issued January 5, 1911.] *Free.*
424. Directions for using bacterial vaccines. [Issued January 29, 1914.] *Free.*
425. Directions for collecting and forwarding material for clinical and pathological laboratory examinations. [Issued February 20, 1914.] *Free.*
426. Publications. 1911. [Issued August 18, 1911.] *Out of print.*
427. Publications. 1913. [Issued April 25, 1913.] *Out of print.*
428. The Philippine Journal of Science and other publications. Bureau of Science. 1915. *Free.*
429. Industrial resources of the Philippine Islands. [Issued February 10, 1914.] [Reprinted for distribution at the Panama-Pacific International Exposition. 1915. Issued Feb. 10, 1915.] *Free.*
430. Riquezas industriales de las Islas Filipinas. [Issued February 16, 1914.] *Free.*
431. Tables of equivalent weights and measures. By Alvin J. Cox. Manila, 1908. $0.05.
433. Notas de interés para los hacenderos de azúcar. 1915. (A 4-page leaflet for distribution at the Silay, Occidental Negros, Exposition and Carnival.) [Issued Jan. 30, 1915.]
434. Philippine fishes. 1915. (A booklet with colored half-tone reproductions of 18 Philippine fishes.) $0.25.
435. Post cards. The same subjects as No. 434. $0.025 each; $0.25 per dozen.

ANNUAL REPORTS *

201. Fifth Annual Report of the Director of the Bureau of Science, for the Year ending August 1, 1906. Manila, 1906. *Out of print.*
202. Sixth Annual Report of the Director of the Bureau of Science, for the Year ending August 1, 1907. Manila, 1908.
203. Seventh Annual Report of the Director of the Bureau of Science, for the Year ending August 1, 1908. Manila, 1909. *Out of print.*
204. Eighth Annual Report of the Bureau of Science, for the Year ending August 1, 1909. Manila, 1910.
205. Ninth Annual Report of the Director of the Bureau of Science, for the Year ending August 1, 1910. Manila, 1911.
206. Tenth Annual Report of the Director of the Bureau of Science, for the Year ending August 1, 1911. Manila, 1912.
207. Eleventh Annual Report of the Bureau of Science, for the Year ending August 1, 1912. Manila, 1913. *Out of print.*
208. Twelfth Annual Report of the Bureau of Science, Philippine Islands, for the Year ending June 30, 1913. Manila, 1913.

DIVISION OF ETHNOLOGY

406. *Vol. IV, Part II, 1908.*—History of Sulu. By Najeeb M. Saleeby. Paper, $0.75.
407. *Vol. V, Part I and Part II, 1908.*—The Batán Dialect as a Member of the Philippine Group of Languages. By Otto Scheerer. "F" and "V" in Philippine Languages. By C. E. Conant. Paper, $0.80.
408. *Vol. V, Part III.*—A Vocabulary of the Igorot Languages as Spoken by the Bontok Igorots. By the Rev. Walter Clayton Clapp. Igorot-English, English-Igorot. Paper, $0.75.
421. *Vol. V, Part IV.*—A Vocabulary of Bontoc Stems and their Derivatives. By Margaret P. Waterman. Paper, $0.75.
422. *Vol. V, Part V.*—A Vocabulary and Phrase Book of the Lanao Moro Dialect. By Charles W. Elliott. Paper, $0.50.
410. *Vol. VI, Part I.*—The Subanuns of Sindangan Bay. By E. B. Christie. Paper, $1.25.
409. Directions for Ethnographic Observations and Collections. 1908. *For free distribution.*

DIVISION OF MINES

301. *1908.*—The Mineral Resources of the Philippine Islands, with a Statement of the Production of Commercial Mineral Products during the year 1907, issued by Warren D. Smith, chief of the division of mines.
302. *1909.*—The Mineral Resources . . . during the year 1908.
303. *1910.*—The Mineral Resources . . . during the year 1909. *Out of print.*
304. *1911.*—The Mineral Resources . . . during the year 1910.
305. *1912.*—The Mineral Resources of the Philippine Islands for the year 1911 issued by the Division of Mines, Bureau of Science.
306. *1913.*—The Mineral Resources . . . for the year 1912.
307. *1914.*—The Mineral Resources . . . for the year 1913.

* For previous annual reports, see under the heading Bureau of Government Laboratories.

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TEXT FIGURES

MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1915

PHILIPPINE MINING POSSIBILITIES

By Victor E. Lednicky

There are numerous mineral districts in the Philippine Archipelago that are known to be of economic value. At present the most important of these are the gold districts. In these Masbate still maintains its lead in production. The Mambulao-Paracale dredging district comes second, with Benguet a rather distant third. Other minor districts produce some gold, but their output will not total 200,000 pesos.[1]

There are three districts in which iron ore is to be had in quantity and several where deposits of manganese and copper occur. A small amount of the iron is being mined in Bulacan, but practically nothing is being done with the copper or the manganese.

The mining at present being carried on in the Philippine Islands is limited to a few regions, but there is no certainty that these are the richest, as so much of the country remains to be explored. There are 1,600 named islands in the Archipelago of which many are known to contain economic minerals and many of which are almost entirely unexplored.

The Bureau of Science has started to map the available deposits for the public, but this work proceeds very slowly because of the lack of geologists. As it is, the work is limited to examining known deposits, and there is no time for more extensive or exploratory geologic work.

Intelligent, systematic prospecting should be encouraged in every way and not be restricted to a limited, somewhat known, area as is being done at present. There are probably less than one hundred real prospectors in the Islands, and a large percentage of these are more or less inactive.

Systematic prospecting should be much easier here than in other countries. The chief handicap is the rank tropical vegeta-

[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

tion which conceals any outcropping mineral deposits that otherwise might be seen. However, this difficulty is more than compensated by favorable climatic conditions and the deep-cut ravines and stream courses which make available excellent sections for the study of the stratigraphy.

The heavy rainfall has probably prevented large deposits of secondary minerals. The reason for this may easily be explained by a geologist who has examined a tropical country before and after one of the torrential downpours and noticed the excessive denudation by the water. The water carries away great quantities of the surface soil, cuts new ravines, and often changes the whole contour of a locality in one small storm.

The Bureau of Science has answered numerous requests regarding the mineral resources of the Islands and the possibilities for investment. Owing to large unexplored areas of the Philippines, in many cases our information has been meager but of sufficient interest to attract several examining engineers to the Islands during the year. Frequently these men were unable to devote the time necessary to a study of the mineral deposits of the Islands, but in all cases they have shown a live interest and some have used extra time to visit the few already exploited districts. Some of these men have stated their intention of returning with an organized corps of competent assistants and doing the work properly.

Through the discovery of flotation and other cheap methods of concentration many deposits which a few years ago were of too low grade have now become valuable. Such deposits should be reconsidered for investment.

The mining enterprises of the Philippines are yet in their infancy, and any new discovery or development is watched with great interest by all people connected with the business.

STATISTICS OF MINERAL PRODUCTION IN THE PHILIPPINES IN 1915

By VICTOR E. LEDNICKY

TABLE I.—*Mineral products of the Philippine Islands, for the calendar years 1907 to 1915.*

Product.	1907		1908		1909	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Metallic:		*Pesos.*[a]		*Pesos.*		*Pesos.*
Iron ....metric tons..	132	19,536	96.5	17,500	78	31,078
Silver[b] ....fine grams..	2,581	110	73,093	2,491	93,310	3,120
Gold ....do....	141,209	187,647	326,897	434,500	372,557	495,194
Copper ......kilograms fine..			91	52		
Manganese						12,500
Total value of metallic		207,293		454,543		541,892
Nonmetallic:						
Coal ....metric tons..	4,123	26,799	10,035	77,166	30,336	197,184
Clay products[c]				421,628		422,840
Lime[c]				20,000		69,656
Sand and gravel				206,360		325,050
Stone				149,930		311,177
Salt[c] ....metric tons..						375,368
Mineral waters ....liters..			268,440	53,688	401,000	80,200
Total value of nonmetallic..		26,799		928,772		1,781,475
Grand total...............		234,092		1,383,315		2,323,367

Product.	1910		1911		1912	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Metallic:		*Pesos.*		*Pesos.*		*Pesos.*
Iron ....metric tons..	50	20,023	37	29,159	141	49,272
Silver[b] ....fine grams..	55,986	1,944	105,191	3,606	221,487	8,664
Gold ....do....	232,311	308,860	285,840	379,906	857,896	1,140,424
Copper.......kilograms fine..	1,809	464	1,100	600		
Manganese						
Total value of metallic		331,291		413,271		1,198,360
Nonmetallic:						
Coal ....metric tons..	28,655	176,255	20,000	130,000	2,720	20,200
Clay products[c]		430,000		450,000		453,000
Lime[c]		70,000		90,000		92,026
Sand and gravel............		293,456		477,344		468,758
Stone		372,575		665,795		651,049
Salt[c] ....metric tons..		380,000	18,333	550,000	19,147	574,511
Mineral waters ....liters..	230,000	46,000	300,000	60,000	264,871	55,849
Total value of nonmetallic..		1,768,286		2,413,139		2,315,885
Grand total...............		2,099,577		2,826,410		3,514,745

Footnotes are at the end of the table, page 10.

TABLE I.—*Mineral products of the Philippine Islands, for the calendar years 1907 to 1915*—**Continued.**

Product.	1913		1914		1915	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Metallic:		*Pesos.*		*Pesos.*		*Pesos.*
Iron ....metric tons..	227	64,471	199	56,274	96	22,694
Silver[b] ....fine grams..	....	....	10,000	9,878	486,917	15,665
Gold ....do....	42,011	1,736,724	58,235	2,349,267	1,981,587	2,633,528
Copper ......kilograms fine..	....	....	....	....	....	....
Manganese	....	....	....	....	....	....
Total value of metallic	....	1,801,195	....	2,415,419	....	2,671,887
Nonmetallic:[f]						
Coal[d] ....metric tons..	....	....	....	....	....	....
Clay products[c]	....	460,000	....	465,000	....	475,000
Lime[c]	11,050	102,700	11,000	100,000	12,520	144,000
Sand and gravel[e]	689,011	595,645	723,461	625,429	650,200	580,580
Stone[e]	197,039	350,041	206,890	367,543	267,910	341,119
Salt[c] ....metric tons..	19,500	575,000	20,000	590,000	22,500	600,000
Mineral waters ....liters..	270,000	60,000	293,381	50,000	305,400	55,000
Total value of nonmetallic..	....	2,143,386	....	2,197,972	....	2,195,699
Grand total................	....	3,944,581	....	4,613,391	....	4,867,586

[a] One peso Philippine currency equals 50 cents United States currency.

[b] The gold bullion produced carries from 5 to 30 per cent of silver as a natural alloy.

[c] The manufacture of this product is a household industry in a very large part of the Islands. Statistics are, therefore, not available, and estimates are approximate.

[d] No economic production.

[e] Production of the Bureau of Public Works, which is the largest single producer, estimated for 1914.

[f] The estimated productions are based on a comparison of the reported outputs with those of previous years.

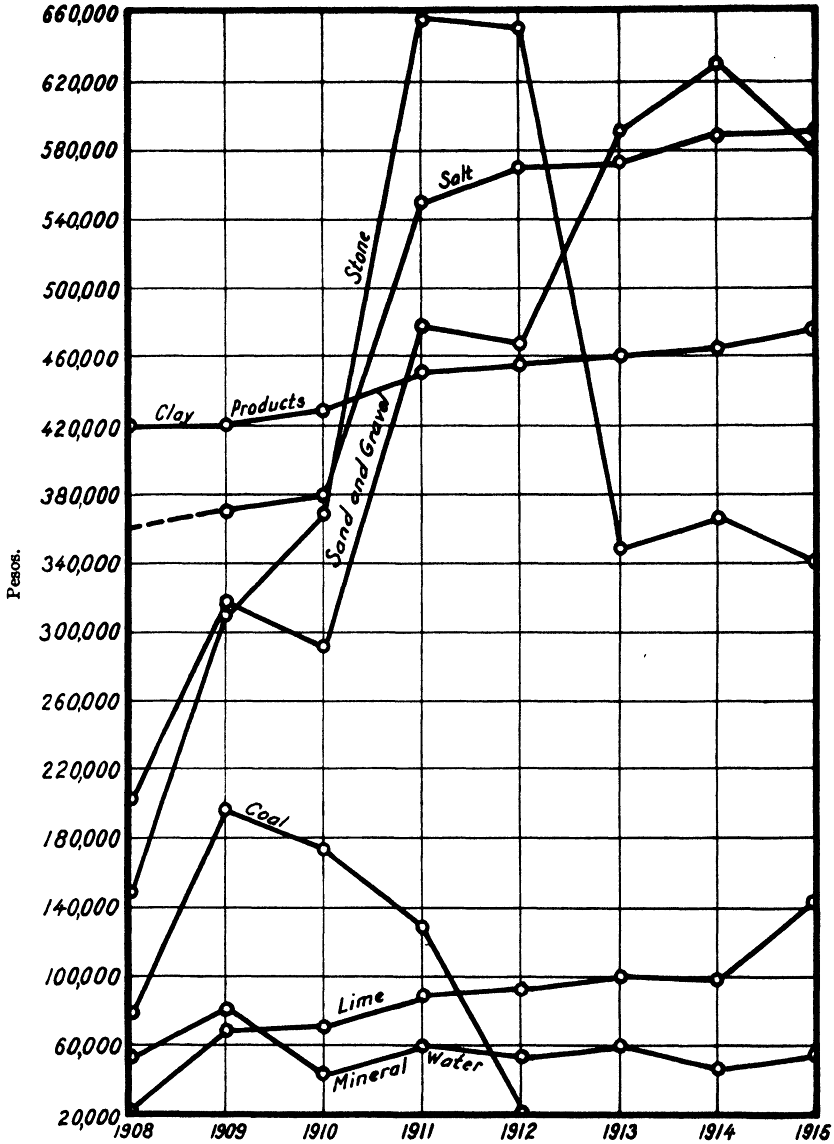

FIG. 1. Production of nonmetallic minerals.

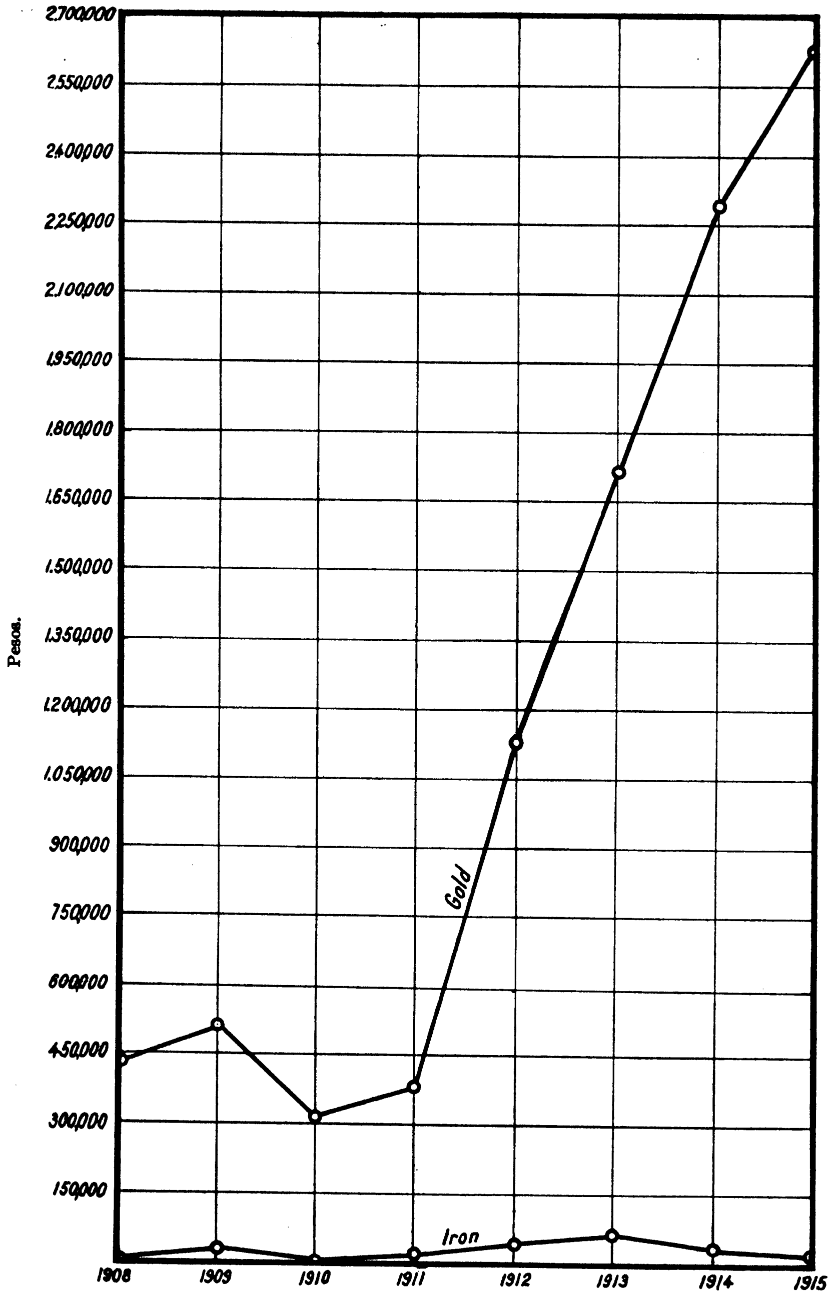

FIG. 2. Production of metallic minerals.

MINING IN THE PHILIPPINE ISLANDS IN 1915

By Victor E. Lednicky

Since 1910 the gold production of the Islands has been steadily increasing. The past year was no exception; 1,981,587 grams of fine gold, worth 2,633,528 pesos,[1] are known to have been recovered—an increase of 12.1 per cent over the production of 1914. The increase in 1914 over 1913 was 35.2 per cent, or almost three times the increase in 1915. A large part of this relative decrease in rate of production is due to a low production in the dredging districts, as several of the dredges were out of commission some of the time due to stormy weather and mishaps. Part of the decrease may be apparent, rather than real, since a new taxation law has been operative, and it is possible that small buyers are getting gold which is not sent through the regular channels and consequently is not included in the statistics.

The Aroroy district, on Masbate, still maintains its lead in the gold production of the Islands. The three mines, the Colorado, Syndicate, and Keystone, continued to operate, and all have had a very successful year. Since 1911 the Colorado Mining Company has been operating its 20-stamp cyanide mill; in 1915 it has mined and milled 55,000 tons of ore, representing a greater output than that of any previous year. The management is still keeping the development work well ahead of the mining, but as yet it has not extended its activities beyond Mount Bagadella, where the principal workings are located. In anticipation of any possible fuel difficulties, a 500-horsepower McIntosh-Seymour Diesel engine is being erected to replace the steam plant. This installation will undoubtedly prove economical. The company has also solved the transportation problem by using auto trucks, which so far have proved successful.

The Keystone Mining Company reports a reserve of nearly one year of ore that will average about 20 pesos per ton. The mill has been run chiefly on ore from development work, and for this reason most of the ore blocked out is intact. Difficulties have been encountered in cyaniding some of the ore owing to the presence of colloids, but according to last reports these have been successfully overcome. The company is preparing to install a 6-stamp individual mortar mill to increase its capacity.

[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

The Syndicate has been producing steadily and has paid one dividend. Power troubles cut down the output somewhat, but they will soon be corrected. One of the old engines is being repaired, and a new 150-horsepower one has been purchased. With these improvements the company will have a total of 450 effective horsepower.

Some newly discovered veins on Masbate give promise of making good mines, and they are being opened rapidly. Several of the older prospects that are being developed have enough ore in sight to warrant mills, but investigation is still being carried on in them to avoid the mistake of building too soon.

The Benguet district has again begun to produce a noticeable amount of gold. The Benguet Consolidated Mining Company is the largest producer. It started milling in the latter part of September after erecting its mill in a very short time, and though the various difficulties that are to be expected in starting a new plant were encountered, these were not serious. Frequent delays in obtaining supplies were caused by poor freighting conditions, and this, together with a shortage of water for power purposes, kept the output below that anticipated, but at present the mill is running smoothly. The company expects to take out about 500,000 pesos this year. Some new veins which give indications of good tonnage have been opened in the mine.

Mr. L. O. Hibbard has continued operating the old Headwaters lease. He has made several improvements in milling, and his white sugar-quartz ore has proved to be excellent amalgamation material.

The Acupan Mining Company on Acupan Creek in July started a small demonstration mill to test its ore. The small mill has been a success, and the output has paid all expenses of operation. A description of this company's property and mill is given on page 37.

Several new properties are being worked, and some new discoveries have been made. Howard and O'Neal, two well-known prospectors in the Benguet district, have located some claims on Acupan Hill. Assays from their veins show good ore values. The owners state that they have a vein which is 15 meters wide where it has been exposed. Another company, called the Riqueza Nacional, operating on Filipino capital, has developed some property near the old Antimok Valley Company claims. Assays made at the Bureau of Science and elsewhere show that the company has some paying ore.

The Camote-Clayton mine, which has been idle during the latter part of the year, is to be reopened. A company with sufficient capital to develop the property has been formed, and if the prospect continues to be favorable, a mill will be installed. Judging by the results obtained from the same property by Mr. John Reavis, it is probable that the mine will prove satisfactory.

The old Fienza ground, of which the ownership had been in dispute for many years and was finally allotted to the Igorot Fienza by the Supreme Court, has been sold to a company of Baguio and Manila capitalists, who intend to develop the property and to install a mill as soon as the necessary development work has been completed.

Mr. George Mead has been working the placer deposit below Benguet. It is reported that some profitable gold values have been recovered. The sands also contain a little platinum.

Capt. Thomas Leonard brought to the Bureau of Science some samples of placer gold from Alabat Island. They were specimens varying from pieces the size of rice grains to nuggets weighing about 15 grams. The gold proves to be the purest ever found in the Philippine Islands, assaying 950 fine. Captain Leonard in company with some Manila men staked most of the available property. At present they are experiencing a shortage of water, but they intend working as soon as the rainy season starts. The gold is found as placer deposits, but some promising veins have also been exposed.

The Igorot miners working in the Palidan slide at Suyoc, Mountain Province, had a very successful year considering the protracted rainy season. They mined about 60,000 pesos' worth of gold in about three months of work. Several rich pockets were struck, and the general average of the vein was high. It is supposed that they have about two more years of work until the vein runs out of their property.

The placer-gold deposits on Binabay River, Mindoro, have been exploited by a local company. Tests showed the ground to be rich, and a movement is under way to install small sluices to recover the gold. Owing to the climatic conditions it is very difficult to do anything with the ground, and proper preparations will be necessary before any extensive workings can be carried on. Transportation offers difficulties at present which, however, can be readily surmounted. Sufficient water can be obtained for extensive mining at small cost, as there are no excessively dry seasons in that part of Mindoro.

Mr. Albert Villager, who has been prospecting on Panaon Island, Leyte Province, is still doing development work and has found good values.

The Surigao Gold Mining Company has continued its prospecting and development work on the veins at Cansuran. Very little is known concerning the extent of the latter deposits, but it is reported that some excellent ore has been found.

It is probable that more interest has been shown in copper during the last three months of 1915 than had been shown for several years. The high price of copper has attracted attention to the copper deposits of the Philippine Islands. Considerable prospecting for copper deposits has been done, and some development work is being carried on.

The Zambales deposit, described in last year's Mineral Resources, has been further developed this year, with encouraging results. Some stringers of almost pure chalcocite have been uncovered, and it is possible that when the development work is carried on extensively a large body of low-grade ore may be found. The owners deserve credit for the way in which they have carried on their prospecting work. Lack of transportation is at present one of the drawbacks to the development of the property. It is rumored that a foreign company has requested options on the claims.

Renewed interest has been shown in the Mancayan deposit, and negotiations for its sale have been reopened by certain companies which had previously tried to buy it. With the prevailing high price of copper and favorable market conditions there is no reason why the property cannot be made to produce profitably.

The copper deposit at Sual, in Pangasinan Province, is being opened up in a new location, a practical miner doing the work under the direction of an engineer. The surface indications are good, and a tunnel which has been driven has cut even better values below the outcrop. The company expects to block out enough ore to make the prospects of interest to outside investors.

Mr. John Gillies, a well-known mining man in Manila, has interested capital in the Mancayan-Suyoc district. He has installed a small arrastra on a property at Cayan near the Palidan slide and has done considerable development work. A vein of ore over 16 meters wide which carries gold, silver, copper, and zinc values has been crosscut. An attempt will be made to concentrate this ore and to ship the concentrates to Australia for smelting. With the present high price of metals it is possible that this can be done profitably. Money is also being raised to build a stamp mill below the property just mentioned, in order to handle the gold ore from a claim next to the Palidan. Water will be brought from a distant creek by a flume, and the overburden will be sluiced off from the vein in a manner similar to that employed by the Igorots in mining. The vein will then be mined, and the ore will be trammed to the mill. As the vein which is to be exploited is a continuation of the old Palidan vein, and since the ore has proved rich in the past, it is probable that the undertaking will be profitable.

Prospecting on Marinduque Island has been continued. In addition to the lead ore which has been known for some time, a promising copper prospect has been found.

Mr. Montague still holds his claims near Batangas, but has done very little work on them beyond that necessary to hold the property.

The manganese deposits of Ilocos Norte have been the subject of much inquiry from possible investors. At present the owners are exploring the property to determine the extent of the deposit. It is reported that a Japanese market has been found for the ore. Conditions for handling the ore are very good, as the returning Japanese coal boats should be available. The manganese has been described in the previous numbers of the Mineral Resources. There is no doubt that it is of good quality.

PHILIPPINE GOLD DREDGING

By Frank B. Ingersoll [1]

The general impression to-day is that prior to the installation by an American company of a small Risdon dredge in Masbate in 1905 gold dredging was unknown in the Philippine Islands. This needs some explanation. In 1896 a syndicate of Manila Spaniards constructed a small bucket dredge and put it to work on Paracale River in Camarines Norte Province.

Judged by to-day's standards, this dredge would indeed be a Lilliputian. Its construction was crude, and it had not to exceed four or five horsepower. Its capacity could not have been over 12 or 15 cubic meters (15 or 20 cubic yards) a day. It could not dredge to a depth of over 3⅝ meters (12 feet). It did not even wash the dirt it excavated. This was dumped into boats and conveyed to a puddling mill on the bank of the river.

Just as operations were being begun, the Philippine insurrection stopped all mining in the Camarines. For years the frame of this dredge stood rotting on an island in the river where a high tide had beached it, and it finally fell to pieces. Gradually most of the metal parts of consequence were carried off by vandals. To-day several of the buckets are hanging on the walls of houses in Paracale where they serve as flower pots.

In 1905 the Risdon dredge referred to was built on Guinobatan River in the Aroroy mining district of Masbate. The project was a failure because of prematurely placing a working plant on an untested property. After working unsuccessfully for a few months, operations were suspended.

A "sister" dredge was installed in 1906 by another American company on Lanan River in the same district. It operated for a longer period, but with unsatisfactory results, being apparently unsuited to the conditions encountered, and was finally wrecked by a typhoon.

The first successful gold dredging in the Philippines was on Paracale River in the locality where the Spaniards launched their pigmy dredge in 1896. The ground had in the meantime been acquired by American residents of the Islands who succeeded

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[1] President, Philippine Exploration Company; president, Malaguit Dredging Company.

in interesting New Zealand capitalists. In February, 1907, active work commenced on the construction of a hull to receive second-hand machinery brought from New Zealand.

In November of the same year dredging operations were started, but owing to a defective boiler which had to be replaced, work was suspended until late in the following April.

Considering the small amount of dirt it handled, the early record of this dredge is phenomenal. The period from May 25, 1908, to July 1, 1909, during which there were many stops for repairs, gave 72,369 cubic meters (94,600 cubic yards), handled with a return of 155,050 grams (4,985 ounces) of gold, valued at 179,462 pesos.[2] This is an average extraction of a trifle under 2.48 pesos per cubic meter (1.90 pesos per cubic yard).

It was this record that attracted attention to the possibilities of Philippine gold dredging, caused the investment of considerable local and foreign capital, and gave to the industry the impetus that has brought it up to its present important rating.

As a direct result of the successful Paracale venture, a Philippine company bought the machinery of the Risdon dredge on Guinobatan River in Masbate and mounted it on a new hull in the vicinity of Paracale River. This work was begun late in 1908 and completed early the following year. The dredge proved to be unfitted to handle the ground upon which it was placed, and after several months of operation at a loss, it was closed. In 1910 it was shifted to Malaguit River in the same district and was operated profitably for nearly four years.

The success of the concern, which was the pioneer in Paracale dredging, stimulated another New Zealand corporation, the Stanley-Paracale Gold Dredging Company, to enter the field and to install in 1909 another dredge with second-hand machinery on ground in the upper part of Paracale Valley. After several changes of ownership, considerable litigation, and numerous physical mishaps, parts of the original plant are still working. This dredge, now operated by the Maximelo Gold Dredging Company, is an open sluice box or flume type with a loose-connected line of 5-foot buckets.

Both the pioneer Paracale dredge and the Risdon dredge were originally equipped with revolving screens and the standard type of gold-saving tables, the first using expanded metal and coco matting and the second Hungarian riffles with matting.

[2] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

Later both were converted to the flume type. The Paracale buckets had a capacity of 4½ and the Risdon of 3¼ cubic feet.

The "old Paracale" dredge sank in the river in September, 1910, but was rebuilt with a new hull and resumed work early in 1911. It is still operating, but now has buckets of 6-foot capacity.

The Australian syndicate which succeeded the New Zealand company (the "old Paracale company") acquired other holdings on Paracale River and now has four dredges in operation. The three later dredges have close-connected bucket lines of the capacity of 6, 7, and 8½ cubic feet, respectively. All four of the dredges are of the New Zealand or Australian type. Each has clay sluices which run parallel to the gold-saving sluices and are used to carry off the overburden. All are equipped with riffles, but no mercury is used.

The first dredge of the modern American or California type to be installed in the Philippine Islands was that of the Gumaos Placer Company, which was built in 1912 and started operations in September of that year. It is an "Empire" model and was furnished by the New York Engineering Company. It is equipped with a close-connected line of 5½-foot buckets in which the hood and base are cast integrally with a separate manganese lip. It was the first dredge in the Paracale district to use a tailings elevator. It also has a revolving screen.

The next California-type dredge to be installed was a "Yuba," built in 1914 by the Malaguit Dredging Company on Malaguit River in the Paracale district. In its general features it resembles the Gumaos dredge with the exception that it has no stacking ladder.

The latest addition to the Paracale district fleet is the splendid dredge of the Mambulao Placer Company, which is just commencing operations under the waters of Mambulao Bay. It is the same make as the Gumaos dredge, but is much larger and heavier. It is equipped with a close-connected line of 8½-foot close-connected buckets, and with its powerful machinery it should in actual practice easily have the greatest capacity of any dredge in the Philippine Islands.

Among other innovations in dredge construction the Mambulao boat has the following:

1. Manganese-steel buckets cast in one piece, which includes lip.

2. Steam-electric drive with steaming plant (to burn wood fuel) mounted on board.

3. A clay sluice mounted above the screen through which to pass the "sticky" overburden.

It resembles the Gumaos dredge in having a revolving screen, a close-connected bucket line, and a tailings elevator.

The only Philippine dredge not in the Paracale district is that of an Australian concern, Umeari Gold, Ltd., working on Umeari River, which runs across the narrow northern strip of Tayabas Province, emptying into the Pacific Ocean. Although this dredge has been ready for operation for over a year and a half, it has had extraordinary obstacles with which to contend. The chief of these was an unfortunate selection of the building site, so that after completion the dredge had to dig its way up the river for several miles to the area to be worked. At last report it was not at work on the ground for which it was intended.

It is equipped with an open line of 7-foot buckets and a shaking sluice box. It is the only dredge in the Philippine Islands which has a steel hull. According to reports this feature has been very successful, being strong and apparently well suited for operation in fresh water.

So far as equipment is concerned, the dredges now operating in the Philippine Islands may be grouped as follows:

Hulls.—All dredges in Paracale district, wood; Umeari dredge, steel.

Digging parts.—Mambulao, Gumaos, Malaguit, three Paracale river dredges, close-connected bucket lines; Maximelo, one Paracale River, Umeari, open-connected bucket lines.

Washing apparatus.—Mambulao, Gumaos, Malaguit, revolving screen; Umeari, shaking screen; all Paracale River dredges, including Maximelo, flume type.

Spuds and headlines.—Mambulao, Gumaos, Malaguit, work on spuds; all Paracale dredges, Maximelo, Umeari, work on headlines.

Tailings elevator.—Mambulao, Gumaos.

Fuel.—Steaming plants all use wood fuel; only variation is the Mambulao dredge which burns wood fuel on board to develop electric power.

The surrounding physical conditions in the Philippine Islands, while not worse than the average, require very close study to overcome the drawbacks.

The first difficulty presented is found in the testing work with the view of making close estimates of values. There has been a large amount of payable ground proved up, but it has been necessary to test very closely so as to exclude nonpayable ground from the area to be worked. The deposits are "patchy" or "streaky," and great care must be taken to trace out the gold channels accurately.

In the dredging so far carried on a good deal of clay or other tenacious material has been encountered, in consequence of which the percentage of extraction has not been remarkably high.

There are still numerous unsolved problems as to the best way of handling the material, one of the most important questions being whether or not more water should be used, first, for the purpose of more thoroughly disintegrating the material brought up in the buckets, and secondly, in order better to handle the large amount of "fines" passing over the tables, that is, as to whether or not more water will cause the material to spread more and give the gold a better opportunity to settle behind the riffles.

At the Gumaos property at least 80 per cent of the material handled goes over the tables, by reason of which it has been necessary to employ a very large table area and also to reduce the yardage in order to save the values.

Practically all the bedrock in the Paracale district has been ideal for dredging purposes. It is usually decomposed gneiss or granite and so soft that the bucket lips readily cut into it for a considerable distance and so ensure cleaning up all values which may be hidden in the crevices.

Oregon pine has given much more satisfaction in the construction of dredge hulls in the Paracale district than have the native woods, although this is very likely due to the fact that the best quality of the latter, properly prepared, has not been available. As used, it was not accurately cut, and not being thoroughly cured, it warped. In consequence of this the pieces used in hull construction did not fit together well.

At Paracale most of the dredging has been carried on in tidal rivers, and considerable trouble has been experienced with the steaming outfits by reason of the salt air and the salt water which cause the rapid deterioration of all iron parts. This is probably less noticeable on the Gumaos dredge, which has been working in fresh water at some little distance from the sea, than elsewhere.

There has been considerable difference of opinion as to whether the revolving screen type or the flume type will give the higher percentage of recovery of gold values. The disinterested opinion of observers not directly connected with the operation work seems to be that the revolving screen, which is equipped with high-pressure nozzles to play water in its interior, is best adapted to material containing a high percentage of clay and especially so wherever a tailings elevator is used.

There is also considerable difference of opinion about the use of mercury in the riffles. All of the American-type boats make use of it, while the others do not. The present tendency seems to be an increasing preference for its use.

The American-type dredges all use spuds, while the other dredges do not. It is certain that the spuds have given excellent satisfaction wherever used. On the other hand, it seems possible that on a small dredge, working into narrow corners where a wide swinging cut is impracticable, the headline could well be used.

In the Philippines as elsewhere the round lower tumbler has been used to great advantage, particularly wherever sunken timber is encountered. All the American type dredges have it.

A great deal of interest is manifested in watching the outcome of the innovation of the steam-electric Mambulao dredge, which is the first in this country to employ this method of supplying power. The critics of the plan, while admitting the increased flexibility and other advantages of an electric drive, suggest that all of the benefits and none of the drawbacks of the regular steaming outfit could have been attained by setting up the new plant on dry land and conducting electric power on board.

In the early days of Philippine gold dredging the scarcity of labor, both skilled and unskilled, presented some difficulties, but careful selection and "weeding out" have largely overcome these.

At the outset skilled European labor in the Paracale district was furnished by the New Zealanders who came with the first dredge, and since that time most of it has been drawn from the New Zealand and Australian dredging fields.

The supply of Filipino labor, while scarce and unsatisfactory at first, has gradually improved both in quantity and quality, so that, considering the wages paid, there is little of which to complain.

As a rule the white crew on a Philippine dredge has consisted of a dredgemaster, a mechanic or engineer, and three winchmen. The mechanic's wages average 300 pesos per month and those of the winchmen 250 pesos. The dredgemaster has been paid 400 pesos or more, according to contract.

The native laborer gets 1 peso per day, while assistant machinists, assistant winchmen, and a few others with somewhat advance work get as high as 1.50 pesos per day.

At present in the Paracale district work is carried on for six days of the week, the dredge being shut down from midnight on Saturday to midnight on Sunday. Several reasons are responsible for the substitution of this plan for one of continuous operation, Sundays included.

The machinist and his assistants use Sunday for overhauling the machinery, and the consensus of opinion is that in the long run better results are produced. A general weekly overhauling eliminates numerous small stops during the work.

Another reason is that the Australian and New Zealand dredgemen who have supplied most of the skilled labor were not accustomed to Sunday work at home, it being prohibited by law. In consequence, while in an emergency they may be called out on Sundays, it has never been popular and it has been deemed better policy not to demand it. With the natives also Sunday work has never been known, and on rare occasions when the dredge continues to operate after Saturday at midnight, it usually happens that next morning the winchman in charge finds that his crew (faithful in attendance on week days) does not put in an appearance.

One company tried the "seven-day week," but discontinued it after a few months as not producing the best results.

The average cost of operation in the Paracale district has been much higher than it should have been. A large factor in this has been, in some cases, the use of plants of small capacity and of inferior gold-saving devices. Again there have been too many companies operating a small number of dredges. With all of them under one management there would be a tremendous saving in operation cost.

An estimate made by the Bureau of Science of the cost per cubic yard, under the best practice, placed the figure at 13.1 centavos, Philippine currency (17.1 centavos per meter). While the figures are not available for a close calculation, it is probable that the average dredging cost in the district from the beginning has been as high as 18 centavos per cubic yard (23.5 centavos per cubic meter). This is exclusive of deterioration and overhead cost.

It is also probably correct that the production per cubic yard handled has averaged as high as 40 centavos (52.3 centavos per cubic meter).

With modern dredges of large capacity and up-to-date gold-saving devices it is certain that the cost could be reduced below 10 centavos per cubic yard (13 centavos per cubic meter). With hydroelectric power in large operations there seems to be no reason why the cost could not further be reduced to 7 centavos per cubic yard (9.1 centavos per cubic meter).

The output from gold dredging in the Paracale district (which covers that of the Philippine Islands) increased from 4,000 pesos (about 114 ounces; 3,545 grams) in 1907 to 1,030,000 pesos (about 28,300 ounces; 880,228 grams) in 1914, an increase of about 25,000 per cent.

The production (exact figures not yet available) during 1915 was less, because some of the dredges from various causes were unable to work their ground continuously.

The production during 1916 will probably equal that of 1914, and 1917 should see a further increase.

The occurrence of gold is very widespread in the Philippine Islands, and it is in many localities noticeable that while large bodies of gold ore (of sufficient size for profitable quartz mining) are lacking, there are innumerable rich stringers from which the small streams, abounding everywhere, wash the gold into the valleys, where the conditions are well adapted for dredging.

The possibility of profitable operation has been demonstrated. In the Paracale field, notwithstanding the excessive operating costs, every plant has shown a profit. Systematic prospecting in other fields has demonstrated the existence of large areas of payable ground.

What is needed in Philippine dredging is the investment of more capital, the installation of larger dredges, and the introduction of modern methods, not only in gold saving but in the business end, so as to introduce system and economy of operation, which are so important in the successful handling of any enterprise.

THE IRON INDUSTRY IN 1915

By VICTOR E. LEDNICKY

The production of iron in the Philippine Islands by crude smelters continues but the industry has fallen off since 1913. The total value of the iron produced in 1915 was 22,694 pesos,[1] or only 40.3 per cent of the amount produced in 1914. As usual these figures represent the value of plowshares and plowpoints cast in the iron district and do not include the points or pans cast from scrap in Manila and other places. The decrease in production is due to several causes, chief of which is the competition of outside manufacturers. A quantity of inferior points and shares made by the Chinese from scrap metal are being put on the market at prices below those of the Bulacan products, and the former are being handled by the small storekeepers to the exclusion of the latter. Light American plows are being introduced into the Islands, and as they are proving as efficient as the crude native plow, their general adoption is only a matter of time.

Several furnaces have been abandoned and only a few new ones have been built during the past year. A steady decrease in the supply of charcoal and a large number of unsold castings in the hands of the producers have so cut down the profit that the business is less popular than formerly.

Several companies have considered the installation of coke furnaces along the railroad, and one company has gone so far as to design a small cupola furnace which it expects to erect in the near future. A combination of auto line and river haulage is being considered to transport the ore to the furnaces.

Table I shows the iron production for 1915.

TABLE I.—*Iron production of the Philippine Islands for 1915.*

Plowshares:	
Size 1	5,736
Size 2	5,615
Size 3	7,326
Plowpoints	8,896
Ore used (metric tons)	240
Charcoal:	
Firings	26
Metric tons used	439
Furnaces in operation	7
Total times in blast	26
Days in blast	301
Iron produced (metric tons)	96
Market value of product (pesos)	22,694

[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

THE SALT INDUSTRY OF THE PHILIPPINE ISLANDS

By T. DAR JUAN [1]

Although many Spanish writers mention commercial salt making as an occupation as early as 1583, no accurate information regarding the methods used or the approximate annual production could be obtained before 1911.[2]

At present in 105 municipalities, representing 30 provinces, salt is prepared either by solar evaporation or by boiling the concentrated brine in open kettles.

TABLE I.—*Annual production of salt in the Philippine Islands by solar evaporation.*

Province.	Process used.	Production.
		Kilos.
Antique	Filipino	110,254
Bataan	do	142,560
Batangas	do	1,299,870
Bohol	do	27,353
Bulacan	Filipino and Chinese	71,280
Cavite	do	2,005,312
Cebu	Filipino	482,660
Iloilo	do	943,357
Mindoro	do	49,500
Moro	Chinese	991,200
Occidental Negros	Filipino	95,056
Oriental Negros	do	33,896
Palawan	do	34,650
Rizal	Filipino and Chinese	7,055,400

TABLE II.—*Annual production of salt in the Philippine Islands by artificial heat evaporation.*

Province.	Kilos.
Albay	small amount
Ambos Camarines	27,000
Batangas	([a])
Bohol	([a])
Cagayan	40,830

[a] See Table I.

[1] Chief analyst, division of general, inorganic, and physical chemistry, Bureau of Science.

[2] See Cox, Alvin J., The salt industry and resources of the Philippine Islands, *Min. Resources P. I. for 1911* (1912), 63.

TABLE II.—*Annual production of salt in the Philippine Islands by artificial heat evaporation*—Continued.

Province.	Kilos.
Capiz	491,280
Ilocos Norte	783,051
Ilocos Sur	1,983,233
Leyte	2,640
Misamis	40,800
Mountain	11,400
Nueva Vizcaya	125,000
Pangasinan	1,026,835
Samar	2,817
Sorsogon	9,900
Surigao	4,000
Union	445,585
Zambales	356,181

The various methods used in the Philippines for evaporating the sea water have already been described by Cox in the Mineral Resources of the Philippine Islands for 1911.[3] Among these methods the most important and best adapted for the manufacture of salt on a commercial scale is the so-called "iras intsic," or the Chinese, process.

A plant having a surface area of 5,000 square meters produces about 1,800 cavanes, or 89,100 kilograms, of salt, per season of about ninety days when this process is used. The product obtained is coarse and not usually of the best quality, as it contains magnesium and calcium salts and other impurities; however, if proper precautions are taken in constructing the plant and in the manipulations during the process of evaporation, the quality of the salt can be improved and the output for a given area increased considerably.

TABLE III.—*The magnesia and lime content of the salt by iras intsic process.*

[Numbers give percentages.]

Source.	Calcium oxide.	Magnesium oxide.
Parañaque	1.24	0.84
Malabon	1.66	1.93
Obando	0.79	1.81

So far as we have been able to determine, the area devoted to crystallizing ponds in plants using the Chinese process is one sixth to one fifth, excluding the first evaporation reservoir which is usually a fish pond, or even more of the area covered by the

[3] See also *Phil. Journ. Sci., Sec. A* (1915), **10**, 315.

plant. However, taking into consideration the fact that for the more complete separation of the less soluble salt the volume of the brine should be reduced more than is done in common practice, the above ratio is much larger than is necessary.

In order to carry on the process of evaporation in the most efficient way, the following facts should be given due consideration.

The rate of evaporation of the brine decreases as the concentration is increased. Accordingly, in order to counteract retarded evaporation in the various steps of the process, a slightly greater than proportional surface area is needed in succeeding concentration reservoirs. This fact is almost negligible except in fairly concentrated brine and is probably more than compensated by seepage. The latter varies, depending on the nature of the soil, and the average should be determined and taken into consideration in the construction of a plant.

The capacity and surface area of the evaporation reservoirs of any row should be proportional to the quantity of brine delivered from the reservoirs of the preceding row.

The specific gravity of the brine should be controlled in such a way that each row of evaporation reservoirs will receive and deliver a brine of definite specific gravity.

The area occupied by the crystallization vats should be as small as possible to accommodate the brine concentrated in the evaporation reservoirs, for in that way a given quantity of salt can be obtained with less labor.

If we neglect the effect of the precipitation of the less soluble salts (calcium sulphate, calcium and magnesium carbonates, oxide of iron, and alumina) on the density of the brine during the process of concentration, we can establish for practical purposes that the density of the brine is inversely proportional to its volume and for a given depth is inversely proportional to the superficial area. On this basis the approximate volume of the brine at any given density may be determined and the corresponding size of the concentration reservoir to contain it may be calculated.

The brine should not be transferred to crystallizing ponds until the salt is ready to crystallize out (specific gravity, 1.205 at 25°C.). If there is a proper balance in the plant in at least the last two reservoirs, large quantities of undesirable substances will be removed and a purer grade of salt will result. When the strength of the brine in the crystallizing ponds has attained 1.275 specific gravity (29°C.), it should be drawn off and worked over for the by-product or should be discarded.

Previous to 1913 coarse salt was imported from China into the Philippines in large quantities. Since 1913, however, our importation has decreased considerably as is shown in Table IV.

TABLE IV.—*Source and value of imported salt.*[a]

Source.	1909	1910	1911	1912	1913	1914	1915
	[b] *Pesos.*	*Pesos.*	*Pesos.*	*Pesos.*	*Pesos.*	*Pesos.*	*Pesos.*
United States	274	228	4,060	12,052	7,760	6,484	2,436
United Kingdom	5,008	9,016	6,122	9,976	5,174	6,502	1,135
Belgium		8					
Denmark			136				
France	10		82				
Germany	58	102	112		46	272	46
Spain	22	18	12				
China	135,114	102,996	108,204	98,374		24	33
Singapore	412	342					
All other British East Indies	810	190	2,408	364	260	68	6
Japan			342	1,632		2	
British Australasia	476	598	732	284	804	344	882
Netherlands						34	
Total	142,184	112,550	122,210	122,582	14,044	13,730	4,538

[a] From the Annual Report of the Bureau of Customs for the year ended December 31, 1915.
[b] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

TABLE V.—*Quantity and value of salt exported.*[a]

1913		1914		1915	
Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Kilos.	*Pesos.*	*Kilos.*	*Pesos.*	*Kilos.*	*Pesos.*
23,000	350	46,750	540	187,235	2,315

[a] From the Annual Report of the Bureau of Customs for the year ended December 31, 1915.

Salt pays an import tax of 0.40 peso per 100 kilograms when crude and 1.00 peso per 100 kilograms when ground, powdered, or otherwise manufactured. The fact that when the local supply of coarse salt has equalled the demand we have been able to supply our own needs and furnish a surplus for exportation as is shown in Table V indicates that the import tax imposed upon the imported product is sufficient for the protection of the local industry. If the output increases considerably, salt milling might prove profitable.

Aside from the daily use of common salt as a condiment, this article is also used very extensively in the canning industry and as one of the most important raw materials in the manufacture of caustic soda, hypochlorites, chlorine, hydrochloric acid, and other chemicals. Some of these are of an immediate need in the Philippines in order to give an impulse to new industries and in this way to utilize at an advantage some of our natural resources. From the above considerations the increase of the salt production is of vital importance to the country both from a financial and a chemical standpoint.

PHILIPPINE COALS AND THEIR USE

By F. R. YCASIANO [1]

The first discovery of coal in the Philippines was recorded as early as 1827, and since then many other discoveries have been made showing the existence of coal in many islands of the Archipelago. No serious work of mining was begun until as late as 1890, when operations were started on a small scale both in Cebu and Batan. In 1903 the United States Army began exploration in the western part of Batan known as the Military Reservation, and in the same year a private company started operations in the eastern side of the same island. Both mines have been closed after several years of activity. The Cebu mine was also worked in 1907, but up to 1912, the time of its closing, the work had never been carried on very extensively.

Table I, published by the Bureau of Science, shows the quantity of coal mined in the Philippines from 1842 to 1912; in the latter year all workings had practically stopped.

TABLE I.—*Coal production of the Philippine Islands from 1842 to 1912.*

Year.	Weight.	Value.
	Metric tons.	*Pesos.*
1842-1906	[a] 30,000	450,000
1907	4,123	25,800
1908	10,035	77,166
1909	30,336	197,184
1910	28,655	176,255
1911	20,000	130,000
1912	2,720	20,200

[a] Estimated.

Dalburg [2] has estimated the probable minimum tonnage of the different classes of coal in the most important localities of the Philippine Islands as follows:

TABLE II.—*Minimum tonnage of coal in the most important localities of the Philippines.*

	Metric tons.
Bituminous:	
Burdeus	1,331,200
Sibuguey	3,628,000

[1] Mechanical and testing engineer, division of general, inorganic, and physical chemistry, Bureau of Science.

[2] *Min. Resources P. I. for 1911* (1912), 56.

TABLE II.—*Minimum tonnage of coal in the most important localities of the Philippines*—Continued.

	Metric tons.
Sub-bituminous:	
Liguan	277,600
Camujumayan	14,592,000
Camansi	4,505,600
Mount Licos	5,352,000
Uling	5,792,000
Sugud	154,000
Masbate	612,000
Lignite (black):	
East Batan	24,300,000
Calanaga	2,560,000
Bulalacao	4,096,000
Summary:	
Bituminous	4,959,200
Sub-bituminous	31,285,200
Lignite (black)	30,956,000
Total	67,200,400

Of the total estimated tonnage only 0.016 per cent has been mined, in spite of the large importation of coal into the Islands, which is shown in Table III from the report of the Insular Collector of Customs:

TABLE III.—*Importation of coal and coke.*

	1915		1914		1913	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Coal:	*Kilos.*	*Pesos.*	*Kilos.*	*Pesos.*	*Kilos.*	*Pesos.*
United States	21,358,148	251,402	42,071,830	240,510	55,926,138	333,888
China	39,049,586	164,712	73,724,833	369,766	32,952,840	152,458
Japanese China	38,658,800	161,027	74,846,688	307,338	60,502,800	251,394
British East Indies	18,799,087	114,021	4,825,253	39,690	3,281,920	19,294
Japan	302,570,937	1,890,128	310,196,790	2,080,234	362,414,204	2,169,772
Australasia	57,119,445	283,295	85,211,168	416,730	46,344,067	241,328
British Africa	77,216	456	6,254,496	45,222		
Total	477,633,219	2,865,041	597,131,058	3,499,490	561,421,969	3,168,134
Coke:						
United States	152,408	2,452	154,940	2,270	24,129	458
United Kingdom	26,880	725	84,451	2,428	3,091	82
France					100,000	956
China	297,688	3,121	255,800	2,396	998,062	13,436
Hongkong			4,164	132	6,210	168
Japan	65,504	1,174	100,506	1,274	214,512	3,168
Australasia	615,696	6,395	661,830	7,142	6,128,768	57,138
Total	1,158,176	13,867	1,261,691	15,642	7,474,772	75,406
Total coal and coke:						
United States		253,854		242,780		334,346
Other countries		2,625,054		3,272,352		2,909,194

Any Philippine coals that are to be put on the local market have to compete with those that are imported, especially from Japan, China, and Japanese-China. They would probably also have strong competitors in the coals from Borneo and Indo-China. Most of these coals are found in the local market now, and the consumers have been more or less educated to their use without modification of the present furnaces. Some Philippine coals can be used in the present furnaces as well as the best imported coal, but the greater bulk of the Philippine coals, which fall under the classes of sub-bituminous and lignite, require either modified grates and furnaces or must be used only in producer-gas plants in order to obtain efficient results. For example, the coal mined in the eastern part of Batan has the following average composition:

TABLE IV.—*Average of ten analyses of East Batan coals.*

	Per cent.
Moisture	17.76
Volatile combustible matter	37.20
Fixed carbon	37.72
Ash	7.32
Total sulphur (separately determined)	1.11
Calories	4,791.5

This table shows that the coal contains a high percentage of moisture and volatile combustible matter and, therefore, is unsuited to be fired, with any advantage, under boilers with internal furnaces such as are commonly used in the Philippines and which are well adapted for coals that burn with a short flame.

The necessity of reconstruction of the boiler settings to use coals high in volatile matter was early recognized and pointed out by the Bureau of Science, when Cox [3] said:

> Reconstruction of the present boiler settings in the Archipelago is out of the question. Greater efficiency, therefore, can be obtained only by building additional baffle walls, using a more satisfactory grate, elongating the fire box or heating the air before entering the grate, and these improvements from an economic standpoint can best be tried in the order of enumeration.

The settings of the Bureau of Science boilers were lately reconstructed according to these indications, making the design more suitable for coals which contain a high percentage of volatile matter, and undoubtedly this type of furnace will burn Philippine coal with greater advantage. In its design the following points were especially provided:

1. Avoidance of early contact of the combustible gases with the boiler tubes, so as to prevent the sudden lowering of their

[3] Cox, A. J., *Phil. Journ. Sci., Sec. A* (1908) **3**, 343.

temperature, which results in condensation of the gases, production of smoke, and incomplete combustion.

2. The existence of a large combustion chamber at a very high temperature, before the gases reach the boiler tubes.

3. Sufficient number of baffle walls to mix the gases thoroughly.

4. Auxiliary supply of air in the combustion chamber.

5. Longer distance to be traveled by the gases before reaching the stack.

Any boiler setting erected with the above suggestion and patterned after the Bureau of Science boiler setting will be found to be more suitable for burning Philippine coals.

Before the work of extensively mining Philippine coal high in moisture and volatile combustible matter is seriously undertaken again, it is desirable to carry on further work to ascertain beforehand the type of stationary and marine boiler furnaces most suited to such coal. The practical use of coal high in moisture in marine boiler furnaces if not impossible will be difficult so long as coal low in moisture can be obtained at reasonable prices.

A most excellent means of utilizing low-grade Philippine coals is in producer-gas plants, as shown by the investigation of the Bureau of Science. In 1906 work along this line was begun. After a careful study of the various types of producer-gas apparatus, a suction producer-gas plant especially selected for Philippine coal was installed as an additional unit in the power house of the Bureau of Science. Since 1912 the Bureau of Science has operated this plant very successfully. The gas is used to run a 69- to 75-horsepower 4-cycle gas engine direct-coupled to a 50-kilowatt dynamo. The plant was guaranteed to operate exclusively on Batan coal only for a continuous run of sixteen hours, but after careful trial and the completion of certain alterations in 1913, the Bureau of Science succeeded in running the plant continuously on Batan coal for periods of thirty days and more. The plant has been demonstrated to give exceedingly good results on other coals which are noncaking. This is the first plant of 75-horsepower rating, single unit, which can use lignite, semibituminous, and noncaking coals for more than thirty days of continuous operation, and the work here shows a distinct advance in gas-producer practice and demonstrates its practicability and economy for stationary power.

Table V gives the cost of the production of power by this system.[4]

[4] The costs will vary according to the load factor, location of the power plant, availability of fuel, and facilities of transportation.

TABLE V.—*Cost of production of power.*

[Net capacity of the plant, 44 kilowatts.]

	Pesos.
Total investment, including transportation, foundation, and installation	17,945.00
Fixed charges per annum:	
Interest at 8 per cent	1,435.60
Depreciation at 7 per cent	1,256.15
Maintenance and repairs 3 per cent	538.35
Total	3,230.10
Operating cost (8 hours' daily run):	
Fuel at 8 pesos per ton	927.28
Wages of one power engineer and one fireman	1,825.00
Oil and waste	91.25
Total	2,843.53
Total kilowatt hours for 300 days	74,400
Fixed charges per net kilowatt hour	0.0434
Operating cost per net kilowatt hour	0.0382
Total cost of operation per net kilowatt hour	0.0816
Operating cost (24 hours' daily run), 300 days:	
Fuel at 8 pesos per ton	2,781.84
Wages of three power engineers and three firemen	3,475.00
Oil and waste	205.30
Total	6,462.14
Fixed charges per net kilowatt hour	0.0144
Operating cost per net kilowatt hour	0.0289
Total cost of operation per net kilowatt hour	0.0433

In the above calculations the number of days in a year was taken as three hundred. Both the maintenance and repairs were included in the fixed charges as so much per cent of the capital invested, in order to facilitate the calculation. The water used for cooling the engine and cleaning the gases was not included in the calculation—its cost per kilowatt hour is insignificant.

It has been thoroughly demonstrated that the low-grade Philippine fuel, such as the East Batan coal, can be fired very economically and efficiently and with reliability in a suction producer-gas plant of the type used in the Bureau of Science. It can be also fired with relatively good efficiency in modified boiler settings. The higher-grade Philippine coals can be used directly in the furnaces now in general use. But the most economical use of all classes of these fuels is in a producer-gas plant.

One of the means that will undoubtedly solve the problem of efficient utilization of Philippine coals of all grades, besides their use in the producer-gas plants, will be the installation of machinery to make powdered coal for industrial use and for firing in furnaces of locomotive, marine, and stationary boilers.

THE ACUPAN MINING COMPANY

By V. E. Lednicky

The Acupan Mining Company, a corporation of Baguio and Manila capitalists organized for the purpose of mining gold, controls a group of 25 full claims and fractions of claims located in the southeastern part of the Baguio mineral district. The group lies about 13 kilometers, south 40° east, of the city of Baguio and 2 kilometers south of the old Major mine. Twenty-three of the claims have been located so that they cover the mountain side east of Batuaan Creek, while the other two cover a continuation of the main vein on the west.

TOPOGRAPHY

The main mountain ridge, on which the claims are located, has an elevation of 1,510 meters above sea level and rises 300 meters above the place where the stream uncovers the vein. The side of the mountain is very steep, and it is cut by ravines and surface water courses into a great number of smaller hills and ridges.

GEOLOGY

The general formation is a quartz diorite with intrusions of another rock, probably a variation of the same diorite. Megascopically the diorite is a granular holocrystalline rock containing visible feldspar, hornblende, and quartz. The feldspar and hornblende predominate with an interstitial filling of quartz. The color varies, due to the percentage of hornblende, from a very light color to a dark green. The rock is very hard and does not weather easily.

The gold occurs free and in combination with the sulphides in a vein about 20 meters wide containing narrow stringers of a hard blue quartz carrying the best values. The vein strikes approximately east and west, has an almost vertical dip, and can be traced easily by its surface outcrop for about a kilometer. Not enough work has been done on the vein to determine the character of the deposit. Several small tunnels have been driven for short distances, but none of them has penetrated the oxidized zone. Most of the work has been done on a quartz stringer from 1 to 2 meters wide on the foot wall of the vein, and assays taken at random from the different tunnels showed values of from 10 to 100 pesos [1] per metric ton.

Free gold values are also found in the talus covering the slopes to the north of the vein. It is probable that the gold comes from the erosion and decomposition of the vein matter and has been concentrating there for centuries.

In order to test out the milling qualities of the ore while development work was being carried on, a small mill was erected and started in July. Ore from various parts of the vein was milled, and the results were recorded. The mill consists of three 850-pound stamps followed by silvered plates for amalgamation. After the plates the product goes to an arrastra, where it is subjected to fine grinding and inside amalgamation. The screen product passes over a 4- by 8-foot amalgamation plate and on to a 16-foot Wilfly concentrating table. The tailings from the table go directly to the creek, and the concentrates are stacked for future cyaniding. Water under a 200-foot head furnishes ample power for the 6-foot Pelton wheel of the mill, a small dynamo for lighting, and a small sawmill. Provision has been made for an air compressor, but none has been installed.

The arrastra used for the fine grinding of the ore is very similar to those used in Mexico. It consists of a circular pavement 3.6 meters in diameter with a retaining wall around it and a step in the center. The retaining wall and step are built of concrete, and the pavement is built of diorite slabs about 1 meter long set on end and cemented together. Four bowlders of diorite weighing about 1 ton each are used as dragstones. These are attached by means of chains to two horizontal cross arms supported by a revolving steel spindle. The spindle is connected by a bevel gear to a shaft driven from the water wheel. The greatest efficiency has been obtained with a speed of 12 to 18 revolutions per minute. The fineness of the output can be regulated by raising or lowering the discharge in the retaining wall.

A well-constructed bottom lasts about five months, and a 1-ton dragstone lasts about one month. In order to keep the output more constant, one stone is changed every week.

Some difficulty is experienced with flouring of mercury in the arrastra, but a large percentage is caught either on the plates or on the table.

When the small mill was built, it was calculated by the owners

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[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

that it would pay its own expenses and also pay for a certain amount of development work on the vein. It was found that some of the oxidized ore which they intended milling would not amalgamate and that a blue quartz containing rich free gold was too hard to be ground economically. In order to pay expenses, the talus from the hillside was milled. It has proved very profitable. About 40 tons of ore per twenty-four hours were put through the mill with a monthly extraction of from 1,000 to 2,000 pesos. This pays all expenses and allows for a few hundred pesos in development work. This method of development is very slow, and it will probably be several years before the company has a developed mine. The vein could be developed and blocked very inexpensively, for it is ideally situated. Labor and power are both cheap, and a few thousand pesos judiciously expended would show whether or not the ore body is worth developing.

Oversized Foldout

GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1916

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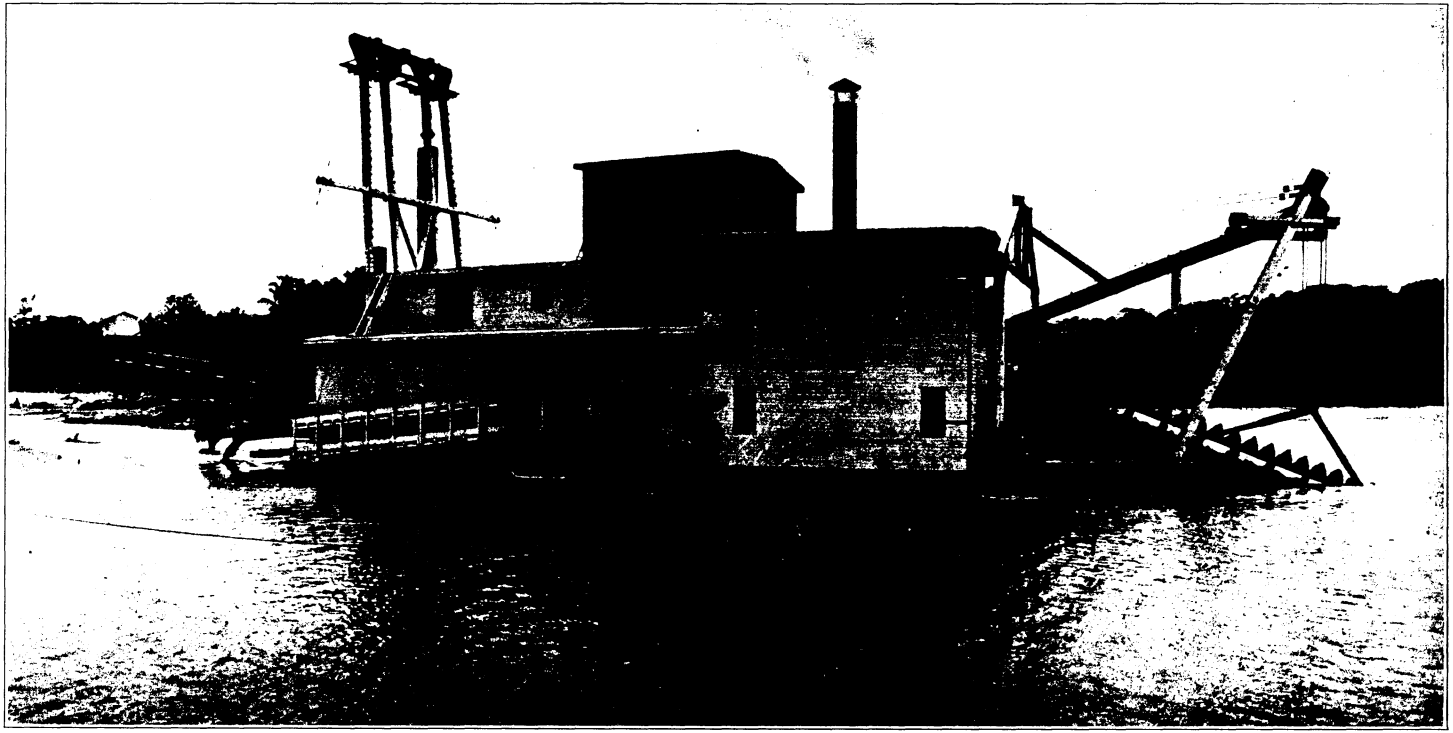

PLATE I. MAMBULAO DREDGE, PROPERTY OF THE MAMBULAO PLACER COMPANY.

GOVERNMENT OF THE PHILIPPINE ISLANDS
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THE DIVISION OF MINES OF THE BUREAU OF SCIENCE

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MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEAR 1916

INTRODUCTION

By Alvin J. Cox

The production of gold of the Philippine Islands has been greater than ever before in her history. The Aroroy district, Masbate, still maintains its lead in the gold production, though Ambos Camarines and Mountain Provinces have been good producers. Many companies have a reserve stock of ore that will average from 16 to 20 pesos [1] in gold per ton. The Benguet district, Mountain Province, shows an increase in production, and it is anticipated that the increase will continue. In many of the districts several new claims are being worked, and some new discoveries have been made. Heretofore the mining for gold has been restricted to certain districts; now there is a tendency to expand to other territory.

The valuable iron ore in the districts of Surigao and Bulacan Provinces and Calambayanga Island, which has been described in the Philippine Journal of Science, is still undeveloped. The lack of transportation and of proper smelting facilities has prevented its exploitation on a large scale, but many small iron castings are produced each year in native furnaces. The exemption of iron ore from the export tax is being agitated.

Copper deposits are known to exist at Mancayan, Mountain Province; in Benguet; Pangasinan; Batangas; Mindoro; Panay; and Mindanao. During the year engineers have examined the deposits at Mancayan with a view to their development. Silver is found alloyed with gold in practically all of the gold deposits in the ratio of one part silver to four parts gold. Its increase in production, therefore, is proportional to the increase in the production of gold. Native silver has been reported. Silver is found associated with galena in Bulacan, Paracale, Marinduque, and Mindanao. A newly discovered 2-meter vein of com-

[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

paratively pure galena has been recently opened in Marinduque and is said to be extensive.

Manganese occurs as psilomelane, pyrolusite, and wad in Ilocos Norte, Pangasinan, Bulacan, Tarlac, and Masbate. Three thousand tons of manganese were mined in Ilocos Norte and shipped to Japan in 1916. Not only have there been many inquiries with regard to manganese, but also with regard to molybdenum, tungsten, antimony minerals, asbestos, corundum, magnesite, sulphur, fire clay, abrasives, alum, artesian and mineral waters, gems, and gypsum, all of which are included in possible Philippine mineral resources.

Bat guano occurs in caves in nearly every province, and the development of this valuable fertilizer has been somewhat increased by the shortage in the world's supply of fertilizers and by decreased importations. The guano can be delivered to any plantation for a fraction of the cost of commercial fertilizers.

The salt manufactured in the Philippine Islands each year is valued at about 500,000 pesos. Sea water evaporated by solar heat is the source of the larger part of this production, but in certain localities, notably north-central Luzon, brine from salt springs is utilized. Although the number of plants engaged in the production of salt has considerably increased, the unusual amount of rain during the dry season and the high cost of transportation for imported salt has curtailed the output and available supply, so that local prices have been very much advanced during the year.

The local price of coal has been considerably advanced during the year. Since several million pesos' worth are imported annually, there should soon be considerable local development. Almost every island in the Archipelago and a majority of the provinces are known to contain coal or lignite. The Bureau of Science has accumulated data concerning the quantity and the quality of the coal in the different fields. Coking coal occurs in Cebu Province. With Philippine coal the Bureau of Science has been able to produce electric power by means of its 67-horsepower Otto suction producer-gas plant at 0.033 peso per net kilowatt hour.

The disturbed world conditions have increased the market for crude oil, and interest is being shown in the development of the petroleum beds of Bondoc Peninsula, Tayabas Province, Luzon, which have been studied by the Bureau of Science and are believed to be worthy of exploration by drilling. Petroleum is known to occur also in Cebu, Iloilo, Capiz, and Leyte Provinces and in Mindanao Island. Commercial quantities of asphaltic materials exist in Leyte, and some exploratory work has been done on the deposits. There is a great abundance of low-grade material from which high-grade asphalt could be extracted.

Imports of Portland cement have continued. The local consumption of Portland cement is certain to increase as the country progresses in financial and industrial importance. The Rizal Cement Company has a small modern plant at Binangonan. The Bureau of Science has made excellent Portland cement from several local raw materials. In Cebu desirable materials occur adjacent to undeveloped coal fields, the fuel from which is suitable for burning cement.

Excellent coralline and crystalline limestone suitable for the manufacture of lime occurs throughout the Archipelago, and experiments of the Bureau of Science show that superior lime can be produced from any of these. The lime heretofore produced is of inferior quality, and much of that used for sugar manufacture and for other chemical purpose has been imported. The increased production of sugar by modern methods has so augmented the demand for lime that there is now a need for the output of large kilns. The crude lime of local manufacture sells for as much as 30 pesos per ton. This price is sufficient to insure a handsome profit for good lime. Hydrated lime should find extensive use for road-building and for waterproofing concrete. In connection with a lime kiln the operation of a bleaching-powder plant and a sand-lime brick plant appears attractive. The value of bleaching powder consumed in Manila alone amounts to 25,000 pesos per annum. Conditions are favorable in the Philippines for the commercial manufacture of bricks, building blocks, tiles, slabs, and ornamental stones from sand and lime. The cost of manufacture is sufficiently low to enable them to compete with other building materials.

STATISTICS OF MINERAL PRODUCTION IN THE PHILIPPINE ISLANDS IN 1916

By VICTORIANO ELICAÑO

TABLE I.—*Mineral products of the Philippine Islands for the calendar year 1916.*

Products.		Quantity.	Value.
Metallic:			*Pesos.*[a]
Iron	metric tons	93	18,864
Silver[b]	fine grams	151,519	7,576
Gold	do	2,265,789	3,011,755
Copper	kilograms fine		
Manganese ore	metric tons	3,000	30,000
Total value of metallic			3,068,195
Nonmetallic:			
Coal	metric tons		
Clay products[c]	do		685,078
Lime[c]	do	12,792	153,075
Sand and gravel[c]	cubic meters	657,937	587,547
Stone[c]	do	211,044	344,871
Salt[c]	metric tons	24,750	742,500
Mineral waters	liters	3,523,630	82,994
Total value of nonmetallic			2,596,065
Grand total			5,664,260

[a] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.
[b] No silver is mined separately, but a small amount is alloyed with the gold.
[c] Estimated production.

TABLE II.—*Philippine gold production by districts for 1916.*

Districts.	Quantity.	Value.
	Fine grams.	*Pesos.*
Masbate	961,524.79	1,278,087.60
Ambos Camarines	600,395.72	798,064.00
Mountain Province	447,600.31	594,963.76
Miscellaneous	256,268.53	340,639.82
Total	2,265,789.35	3,011,755.18

NOTE.—One gram fine gold = 1.32923 pesos.

METAL MINING IN THE PHILIPPINE ISLANDS

By V. E. Lednicky

Several groups of mining engineers examined properties in the Philippines during the past year, and a large amount of time was spent in investigating various claims and deposits. Special interest was shown in the copper and in the placer gold deposits of the Archipelago, although the iron deposits were also examined. The Mancayan copper property was several times the seat of investigation, but at the present writing no satisfactory agreement has been made with the owners for development of the property. Investigation of the copper deposit at Sual, Pangasinan, was made. The results of these examinations are not known, but it is probable that the next year will see several new properties in operation.

The Benguet Consolidated mine, Benguet, had a very successful year; two dividends have been paid, and a large reserve of ore has been developed. There appears to be a large quantity of ore still available. A great amount of difficulty was experienced during the early part of the year with high tailing-loss, but this has been remedied by the installation of additional machinery. The organization has been completed, so that now all operations are well balanced. Trouble has been experienced with the labor, but it has been satisfactorily adjusted.

The Fienza claim, Antimok, Benguet, which has been purchased by the capitalists who have an option on the old Bua property, is promising. Development work in charge of Mr. L. O. Hibbard has been done on both properties, and he has uncovered favorable prospects. If the worked vein in the adjoining Benguet Consolidated claims continues along its probable strike into the Fienza claim, the latter is likely to become a prominent producer in the Philippines. Work on the Bua property shows that it should produce the same quality of low-grade ore as was formerly found in the old Bua mill, but the quantity of ore is uncertain. If 50,000 pesos[1] or more could be expended in development work, a sufficient amount of ore might be disclosed to warrant the erection of a mill.

The Acupan Mining Company of Acupan, Benguet, which has been running a 3-stamp mill and an arrastra, has finally given up the idea of trying to develop the property from the output alone. At first the mill was run on ore from the vein, but on

[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

account of the darkness of the quartz and the smallness of the mill, it was found impossible to stamp enough to pay expenses. On account of this it was decided to run through the loose, low-grade material covering the side of the hill. This material had a value of only 1 to 2 pesos per ton, but it was very soft, and a great quantity was put through the mill in a day. This more than paid expenses, but the development from the earnings was slow, and it was decided to adopt other measures to put the property in shape for a larger mill. With this in view a company agreed to spend 25,000 pesos in developing the mine with an option of erecting a mill for a controlling interest in the property if the development work warranted the undertaking. The development work was started during the latter part of the year; it has continued under Mr. Tom Philips, a mining man from Australia. At the present writing he has tunnels driven in on the vein at different levels for probably a hundred meters, and the indications are encouraging. The vein gives a very satisfactory average in gold. It appears continuous and can be traced across the country for a great distance. It is apparent that slides have taken place along the vein, and it is probable that low-grade ore found on the hillside comes from a decomposition of the vein.

The Howard and O'Neal property, Acupan, Benguet, has been sold, but thus far no extensive development work has been carried on. A tunnel has been driven into the hillside along two veins, and rich streaks have been found. One of the veins contains manganese; it is about 15 meters wide at the outcrop. The matrix of the vein is calcite, but it is to be expected that this will change with depth. There are a number of old Igorot workings on this property, which may indicate veins of value.

Mr. L. O. Hibbard successfully continued working the Headwaters mine, Benguet, until the expiration of his lease, the latter part of the year. At this time the owners sent their engineer to carry on an extensive examination to ascertain whether or not the mine could be worked at a profit on a larger scale. A large amount of good ore was developed, but it was thought not enough to warrant the expenditures necessary for reconstructing the mill. The property was then leased to Messrs. Hagen and Reynolds on a percentage basis. According to the last reports they were doing repair work in the mill and preparing the mine to supply the maximum tonnage of the mill. The pipe line has been repaired, and it seems probable that sufficient water will be obtained to operate the mill during the dry season.

The Camote-Clayton property, Benguet, has been developed during the year, although the mill was not run. It has been reported that the vein from which the rich manganese ore was mined has been picked up again. In case it continues, the prospects are very good for the installation of a mill.

Mr. James Kelly has continued development work on the Muyot property. He is driving a crosscut to intersect the upper vein on his property. The crosscut will not be finished for some time, but when completed will prove a valuable addition to the property, as it will give more backs to the upper vein and also provide drainage.

Mr. John Gillies and associates control the property next to the Palidan slide in the Suyoc district, Mountain Province. They have constructed a flume to bring water from the adjacent stream with which to wash off the overburden, in order to make vein mining much easier. As the Igorots have worked almost to the edge of their property, it is probable that the vein will continue into these claims. Mr. Gillies and his associates have also developed a vein on property below the Palidan, which contains copper, lead, and zinc, with some silver and gold value. The vein, where crosscut, was about 15 meters in width. A small arrastra, worked by a carabao, has been installed, which shows that the ore can be ground very easily and quickly and can be concentrated by any simple washing process. The difficulty in handling this ore is the lack of transportation. If transportation could be obtained, the ore could be shipped to a smelter. It would be valuable during the present shortage of lead and zinc.

The Petit Brothers have continued operations on their claims near the Palidan slide. Their famous "Elizabeth" claim, from which the rich gold-telluride ore exhibited at the St. Louis Fair in 1904 was obtained, is to be reopened. At present the lack of capital prevents any extensive work on the claim.

The Syndicate Mining Company, Masbate, has had a very successful year. The rearrangement of the mill by the new management and several new improvements in mining have enabled them to work at a profit the low-grade ore, of which they have a quantity.

The owners of the Colorado mine, Masbate, have continued operation and report a satisfactory year. The production was not equal to that of 1915, for the mill is being more extensively operated on low-grade ore.

The Keystone Mining Company, Aroroy, Masbate, shut down its mill during the latter part of the year on account of lack of ore. Heretofore the mill had been run mostly on ore from the small amount of development work and surface floats. A small amount of surface ore is still obtainable, but it was decided to attempt to develop ore in the mine rather than to mill the small amount at a loss. It is very difficult in the Keystone to keep to the gold-bearing vein because of the faults, which are very numerous. It is possible that these faults are merely superficial and that with depth the vein may be more continuous.

Mr. Paul Schwab sold the Masbate mill to Messrs. Enberg and Knight, who have discovered a rich vein adjoining the Tengo property. Mr. Schwab has bought a 3-stamp mill; he has installed it farther inland and is milling where some rich surface ore crops out. He is driving tunnels to intersect the vein at river level.

The Enberg and Knight property, Masbate, adjoining the Tengo, shows a rich vein of high-grade ore. The ore is a white quartz, but has fine free gold mixed in it. The gold is almost invisible, even under the microscope, but it amalgamates well and should prove very profitable. Open cuts across the apex show values, which, however, are not equal to those of the vein when cut at depth. At the close of the year a good body of ore had been cut that showed values over a width of 6 meters. The general average is high, because of a rich stringer that yields as much as 1,200 pesos per ton. About 60 meters have been cut along this vein, and the values are more or less continuous although somewhat irregular. Arrangements have been made to borrow a 10-stamp mill from the Tengo Mining Company, which is under option to Manila capitalists pending examination.

The Balete property, Masbate, has been considerably prospected. Several veins of good ore, have been discovered, and it is expected that a large amount of ore, valued at 16 pesos per ton, will be available for milling. The owners have planned to use the 6-individual mortar stamps recently bought by the Keystone from the Bua Mining Company. No attempt will be made to cyanide at present, but when the property warrants the cyaniding process, a proper plant will be installed.

Mr. Albert Villager has continued prospecting and development work on Panaon, and the assays of the ore taken out are promising.

The lead and zinc properties on Marinduque Island have been prospected more thoroughly, and a good vein of almost pure galena has been discovered.

The Alabat Island, Luzon, placer deposits have not been extensively worked, owing to the lack of water. A wood and concrete dam was built across a creek running through the property in an attempt to store the water during the season of greatest rainfall for washing the gravel during the dry season. As no proper examination has ever been made of the deposits, their extent or value is not known. The gold is found in schists and in decomposed green stone, and when a pocket is encountered, it usually yields several ounces of coarse nugget gold. The property is situated near the apex of the mountain range, which forms the backbone of Alabat Island, and the original source of the gold is uncertain. The flats where the river empties also contain gold, and prospecting operations are being carried on to determine if they are valuable. It would be advisable to examine the ground with a prospecting drill and make a proper surface test to see if dredging operations are possible.

The Lubang district properties, Pangasinan, have been given an option for two years to carry on examination and development work. If the prospects continue to development, a mill will be erected to replace the present 3-stamp mill of Mr. Mentzer.

The Agno River placer deposits have been subjected to considerable investigation during the year. Several engineers have made examinations, and from last reports it was understood that an option has been obtained on the property, with a view to carry on extensive prospecting work. Owing to the great depth of the bedrock, difficulty will be encountered in proper sampling. The gold near the surface that can be obtained from sampling pits is very fine, and the yield is rather low to make a dredging proposition feasible. It is probable that the gravel on the bedrock will be rich, although it is known that the gold in the Benguet region from which this is supposed to come is very fine, and no coarse gold deposits are known that would furnish nuggets for Agno River. Large bowlders in the gravel may cause considerable difficulty in dredging. Agno River, like all rivers with steep watersheds in a country with a tropical rainfall, is subject to sudden floods, and great precautions will be necessary in handling a dredge. A dredge for such a river should be constructed differently from those used in quiet waters.

Work on the Binabay River, Mindoro, placer deposits has been continuous throughout the year; flumes have been installed for washing the gravel and bringing in water, but so far, no gold has been marketed. The climatic conditions make it difficult to perform ordinary sluicing. A drag-line system, which could be worked intermittently between heavy rainfalls, should be successful. There is no doubt that there is gold in the river.

During almost the entire year seven dredges were operating in the Ambos Camarines district. A record output was expected, but it fell off somewhat because one dredge sank and it and another were incapacitated for several weeks. The Gumaos dredge, after paying 120 per cent on the investment, in over two years worked over the ground for which it was built, and it is the expectation to move it to some other deposit. The Maximelo dredge is unique in the district, being operated most of the time by only one man. The Mambulao dredge was completed during the latter part of the year. It is the largest and most up-to-date dredge that has been built in the Philippine Islands, and an attempt will be made to dredge the gold from Mambulao Bay. In order to protect the dredge from the sea, work was commenced at the outer edge of workable territory, and the tailings were stacked in such a way as to form a barrier behind which the dredge can be protected. The richest gravel will not be encountered for some time.

The Surigao Gold Mining Company has practically given up its mining work at Cansuran. The spotted character of the ore made it difficult to carry on prospecting and development work. Samples from one place would assay very high, while those immediately adjoining were frequently barren.

The Cansuran Placer Mining Company had a small production owing to an accumulation of difficulties. The Cansuran property has a fair gold deposit, but it presents a rather troublesome problem in successful operation; so far the difficulties have not all been overcome.

Prospecting work has been carried on in Mindanao, and several placer deposits are being tested. Some black sands have shown extraordinary value. Messrs. Kerr and Kane have finished the exploration work on their claims along Hinatuan River. The results of the tests were very satisfactory, and attempts were being made to float the property on the local market. Mr. Kerr, who has had considerable experience in Philippine placer testing, is very enthusiastic concerning his property. Mr. S. E. Rowell is now the owner of claims on Butuan River. It is planned to prospect and test them systematically next year with the view of introducing dredges. Agusan River placer claims have been examined by several possible producers, but the result of their investigations is not known. The area is so large that if it is all worked several dredges will have to be installed adequately to handle the work.

COAL MINING POSSIBILITIES IN THE PHILIPPINE ISLANDS

By V. E. LEDNICKY

Never before has the necessity for Philippine coal production been more emphasized than at present. With the price of Japanese and Australian coal above 30 pesos[1] per ton, there is an excellent opportunity to open the coal deposits of the Islands and to establish a good trade that will continue when conditions have returned to normal.

The price of labor has increased very slowly as compared with the price of coal, and while it is true that interisland shipping is very uncertain, arrangements could be easily made to handle a steady supply of coal to the Manila market.

Granting that the Philippine deposits of coal are not so large as those of Japan, Australia, and other countries and allowing for the lower calorific value of the former, it is certain that a large tonnage could be disposed of by contract with various dealers.

At present some users are burning wood, copra meal, and other substitutes, but would gladly use a lower grade coal than foreign, if it could be purchased at a sufficiently low price to effect a saving. The Government is contemplating a national coal company to develop the deposits and has commenced investigation and surveys of various localities known to contain coal.

The Batan field is again to be reopened, and there is a possibility of this being the main producer. If a new mine is started in place of trying to reopen the old flooded works and if proper care is taken in the mining, the plan should bring about the production of 500 tons per day within a year.

The Cebu deposits at Uling and Danao are being opened by private owners. Messrs. Bryan and London are merely awaiting the proper surveys and papers before beginning to supply their Cebu and Iloilo electric light plants from their mine near Uling.

The Danao field is also being prospected very thoroughly. The quality is well known, and there is no doubt that it will have

[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

a ready sale both for manufacturing and marine purposes, as soon as it is put on the market. At present difficulty is experienced in following the vein at its faults, and the problem of mining will have to be worked out very carefully in order to mine economically. The deposits on Polillo and Alabat Islands were again examined by the Bureau of Science geologists. The Alabat deposits were found to be very unsatisfactory, as they are small and very ununiform, and the quality of coal is poor.

Some of the Polillo coal is commercially economical, but the question of transportation makes it less valuable than the Cebu or Batan deposits.

The coal in southern Mindanao is being examined, but there is some doubt as to the feasibility of mining it. More extensive examinations are to be made, and if favorable, the deposits will be exploited within the next year. Several new coal discoveries have been reported, but examinations of the coal showed it to be of inferior quality.

Samples were again brought from Catanduanes, but no prospecting or development work has been carried on; so very little is known of the actual commercial value of the deposits.

THE MANUFACTURE OF ROOFING TILES *

The disadvantages of the several roofing materials now in use in the Philippines have been pointed out by Argüelles.[1] Nipa is objectionable chiefly because of its inflammability. It is cheap and easily obtained in many localities, but does not last well and must be replaced after a few years. Galvanized iron often gives excellent service, though in some cases it has gone to pieces in a few months. Its cost, however, is the chief factor that prevents its general use. Imported roofing tiles are used on some of the more important buildings, but also have the disadvantage of high cost. This state of affairs has aroused popular interest, and much experimentation has been carried on from time to time. It seems likely that a substitute for nipa will be found.

The extensive use of roofing tiles naturally suggested itself as a solution of the problem some years ago. It is obvious that if tiles could be made from local raw materials they would satisfy most of the requirements. They are cheap, durable, noninflammable, and impervious to water. However, there is one serious disadvantage to ordinary roofing tiles. They are too heavy to be supported by the structure of the average bamboo house.

The Bureau of Science is at present engaged in an effort to produce roofing tiles from local raw materials, which will be sufficiently light for use on the ordinary Philippine houses without materially increasing the roofing supports. The object of this paper is to describe the methods that have been employed in making a number of test tiles. The general appearance of the tiles and the results of tests made on them are favorable and indicate that they may be the means of solving our roofing difficulties. In this work it has been necessary to consider of secondary importance the question of the appearance of the tiles. In many places, such as China and Japan, tile roofs are the most beautiful part of the buildings, but the supporting structures are of brick or stone or of heavy frame; thus the question of weight is not of primary importance, as

* Bureau of Science Press Bulletin 70.

[1] *Phil. Journ. Sci., Sec. A* (1916), 11, 177.

it is here. Ornamental tiles would be impracticable both on account of their weight and the resistance offered to air currents.

The use of roofing tiles in Java is extensive. The following comment is of interest:[2]

A still more important one is the almost universal use of tile roofs. Even in the little kampongs far from the main roads and towns, the most of the little houses have these red roofs of red tile. The tile in use is much lighter in weight than I have ever seen in the Philippines and so requires a lighter and cheaper supporting structure, but is said to be exceedingly durable as compared with a roof of any other kind. The general use of these tile roofs and the consequent loss of waste and gain in comfort impressed me so strongly that I believe there is no other single thing which Philippine industry could borrow from Javanese with so great profit.

Another periodical comments favorably on Java tiles:[3]

Tile roofs are very generally used. The same class of tile seems to be almost universally employed. It is made like a flat elongated S, about 1 centimeter thick. In many native houses these tiles rest upon simple purlins of bamboo. A projection of the tile over the purlin keeps the tiles from sliding off the roof. The tiles are not generally tied down, for heavy wind and rain storms do not prevail with the disastrous consequences of such storms in the Philippines. The tile may prove satisfactory for those portions of our Archipelago where typhoons do not prevail, but it is not believed that, without considerable modification, they would be efficient for structures in Luzon.

Nearly two years ago the Bureau of Science requested a number of Java roofing tiles of the common variety, and when they arrived they were subjected to physical tests. Apparently they had been molded by hand from a mixture of clay and sand.

TABLE I.—*Physical tests on Java roofing tiles.*

Absorption in water.......per cent....	16
Weight.......grams....	1400
Apparent specific gravity.......	2.52
Net surface covered by one tile.......sq. cm....	560
Tiles per square meter.......	17.9
Weight of tiles necessary to cover 1 square meter (exclusive of mortar required).......kilograms....	25.1

By apparent specific gravity is meant the weight, divided by the volume calculated from the dimensions, disregarding the pore space. Counting 50 square meters as the surface of a small bamboo house, the weight of a roof constructed of these tiles would be 1,255 kilograms.

Tiles very similar to these with the advantage of being con-

[2] *Phil. Agr. & Forest.* (1915), 4, 27.
[3] *Bur. Pub. Works Quarter. Bull.* (1916), 5, 6.

siderably lighter can be made from the raw materials found near Manila. Considerable work has been recently done in testing Philippine clays, and this was taken as the basis of the present investigation.[4] Test tiles have been made from a number of clays. A mixture of the clay found on Pasig River near San Pedro Macati, with equal parts of either pulverized volcanic tuff or of sand from the same general locality, was found to be very satisfactory. The materials were dried, thoroughly mixed, and then molded by the wet-mud process. When dry, the tiles were placed in a kiln and burned from twenty-four to thirty-six hours.

During the drying the tiles must be turned at intervals to prevent warping and must be placed in the kiln with considerable care. It is advisable first to place a layer of bricks in the bottom of the kiln. The heating must be very gradual, until the maximum desired temperature is reached. When the burning is completed, the opening in the kiln should be closed, so that the cooling will proceed gradually.

The maximum temperature reached in this experiment was 1,110 degrees C. (cone 02). The methods employed in making these tiles can be easily followed by the average employee and were chosen on that account. There are a number of wood-burning kilns in the Islands that should be satisfactory. The mixture of tuff is superior to the sand mixture in some respects, but the latter is to be recommended because less labor is required for the preparation. The tiles were made in a wooden mold, 20 by 20 centimeters. The physical tests on one tile made from each of the two mixtures are here given.

TABLE II.—*Physical tests on test tiles made from Philippine raw materials.*[a]

Tests.	Clay and tuff.	Clay and sand.
Dimensions .... centimeters..	19 by 19 by 1	19 by 19 by 1
Weight .... grams..	615	729
Absorption .... per cent..	11.9	13.3
Apparent specific gravity	1.89	2.02
Weight per square meter .... kilos..	17	20
Weight per 50 square meters .... do.....	850	1,000

[a] For the chemical analysis and physical tests of this clay when used alone, see *Phil. Journ. Sci., Sec. A* (1916), **11**, 210, sample 2.

On account of the variation usually found in results of tests on clay objects, these results can be considered as only the

[4] *Phil. Journ. Sci., Sec. A* (1916), **11**, 203.

approximate of the average that would be obtained on testing a number of samples. The weight per square meter does not include any cement or mortar that would be necessary to hold the tiles in place. If the tiles could be laid flat, the joints being filled with cement, the total weight per square meter would be only slightly in excess of the value given in the table. If this method were found practicable, it would have many advantages. If it were found necessary to lap the tiles, the weight per square meter would be greater, because at the points of joining there would be two layers of tile and one layer of mortar. There seems to be little doubt that these tiles will give satisfactory service. However, since weight is such an important property of any roofing tile to be used under local conditions, a number of experiments have been made to obtain the lightest tile consistent with other desired characteristics.

When some organic material is mixed with clay, it burns when the tiles are placed in a kiln and has a tendency to leave the tiles light and porous. A number of materials that could be obtained locally were tried, such as straw, ipa, etc. Coal dust was found to have a number of advantages; it has been used in a number of tiles. Various mixes of pulverized Batan coal and Pasig clay were made and tested. The most satisfactory and lightest tile resulted from a mixture of 1,000 parts of Pasig clay to 350 parts of coal. Tiles made from this mixture were apparently satisfactory in all respects, except that they were, of course, not impervious to water. On account of the considerable porosity, they gradually became water-soaked. It was necessary to find some means of waterproofing them. This has been done in two ways: (1) glazing and (2) treating with asphalt or other bituminous substances. Although the porous tiles can be made completely from Philippine materials, either method of waterproofing calls for a small proportion of imported material.

A number of glazes have been tried, but so far the most successful has been the lead glaze. A mixture is made of two parts of red lead and one part of very fine Pasig sand, and sufficient water is added to make a thin paste. The tiles are dipped in this mixture, allowing it to cover one face only. After drying for twenty-four hours, the tiles are reheated to about 1,090° C. (cone 03). Each tile requires about 30 grams of red lead. (At the present price of red lead in Manila—5.20 pesos for 10 kilograms—the glazing for 1 square meter of tile would be about 40 centavos.)

A number of tiles have been glazed by this method. They were found to have excellent properties. Small cells made of paraffin were placed on the glazed surfaces and filled with water, but no water penetrated the tile after standing for forty-eight hours. The tile did not increase in weight, and no moist area was apparent in its undersurface. The results of other tests and measurements are shown in Table III.

TABLE III.—*Tests on glazed tiles.*

Dimension	centimeters	18 by 18 by 0.8
Weight	grams	425
Apparent specific gravity		1.64
Weight per square meter	kilograms	13.17
Weight per 50 square meters	do	658.75

These results are gratifying and indicate that our work is being carried on in the right direction. While the tiles are somewhat frail, due to being thin and porous, it is believed that they have sufficient strength to be durable under ordinary conditions of service. It may be seen that the weight per square meter is not much over half that of the Java tiles.

In impregnating the tiles with bituminous substances,[5] tests were made with coal tar, pitch, and asphalt. The tiles were heated from about 100° to 150° C. and dipped (one face only) into the bituminous material for one minute. The amount absorbed amounted to about 18 or 20 per cent of the total weight of the tile and was, of course, variable.

The tiles dipped in asphalt were apparently most satisfactory. They were impervious to water. The apparent specific gravity of the tile was increased from 1.40 to about 1.70, or about the same as the glazed tile. Approximately 2 kilograms of asphalt would be required for every square meter of tiles. (At the present price of 1.15 pesos per ton, this would be worth 25 centavos per square meter.)

In making a minimum-weight tile roof, the design and the arrangement of the tiles is as important as the structure. The object to be striven for is so to place the tiles that the greatest possible surface will be covered by one tile alone; in other words, the percentage of lap should be a minimum. One type of roofing tile has been extensively manufactured in the Islands. These are semicylindrical in shape. The tiles are so placed on a roof that over half the surface is covered by double tiles, and in some places there are even four thicknesses. It can be seen that a light roof could not be made with tiles of this design. The diamond-shaped tiles seem to be the best for local use, because

[5] *Tonind. Zeitg.* (1916), 40, 316.

the percentage of lapping is low, and little, if any, mortar is required.

In establishing any ceramic industry, it is advisable, after securing a suitable location, thoroughly to test all materials to be used and carry on the work on an experimental basis before fully equipping the establishment for a large production. This precaution is usually necessary, because it sometimes happens that materials do not give as satisfactory results on a large scale as they do in laboratory tests where conditions may be accurately controlled.

We have no data to show just how a roof constructed of these tiles would stand a severe wind storm. It is believed that it would be satisfactory, but modification in the design of the tile and in the method of attaching it to the roof might be necessary. The work at this Bureau, however, has demonstrated that suitable tiles can be economically made, almost entirely from Philippine materials.

THE RIZAL CEMENT PLANT

By J. C. WITT *

The extensive use of cement in the Philippine Islands and its excellent adaptation to construction in the tropics suggested the erection of a plant for its manufacture in the locality of Manila some years ago. Every barrel of cement used was imported, mostly from China, but also from Japan and Indo-China, and in smaller amounts even from the United States and Europe. The annual value of these imports at times considerably exceeded one million pesos.[1] There was reason for the belief that the improvement of the Islands along engineering and architectural lines and the constantly growing general industrial use of the material would call for increased consumption year by year. It seemed that here was a chance for the establishment of a home industry that, in addition to giving employment to several hundred men, would greatly benefit the general public. If cement could be manufactured from local raw materials, the consumer would be saved freight and duty charges, and a big step would be taken toward industrial independence.

Four men who for several years past had been observing the cement situation in Manila, namely, Rev. Father Juan Labargo and Messrs. Antonio M. Barretto, Gustavo Maulini, and Candido Pascual, began active study and investigation of the subject in the spring of 1910. A limestone quarry had been found at San Guillermo, and there was abundant siliceous material in the same locality. A two-year option for the purchase of the quarry was obtained. Samples of the raw materials were sent to a number of laboratories, and favorable reports were received from each of them.

Soon after the incorporation of the company, December 5, 1911, two representatives went to Europe for the purpose of investigating cement-mill machinery. A number of factories were visited, and reports were submitted to the company. Later a contract for the mill machinery was let to Fried. Krupp. To several other German manufacturers contracts were let for barrel-manufacturing machinery, an aërial cableway, electrical equip-

* Technical director.

[1] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.

ment, and a power plant. Most of the equipment arrived in Manila in August, 1914, and the work of installation was begun,

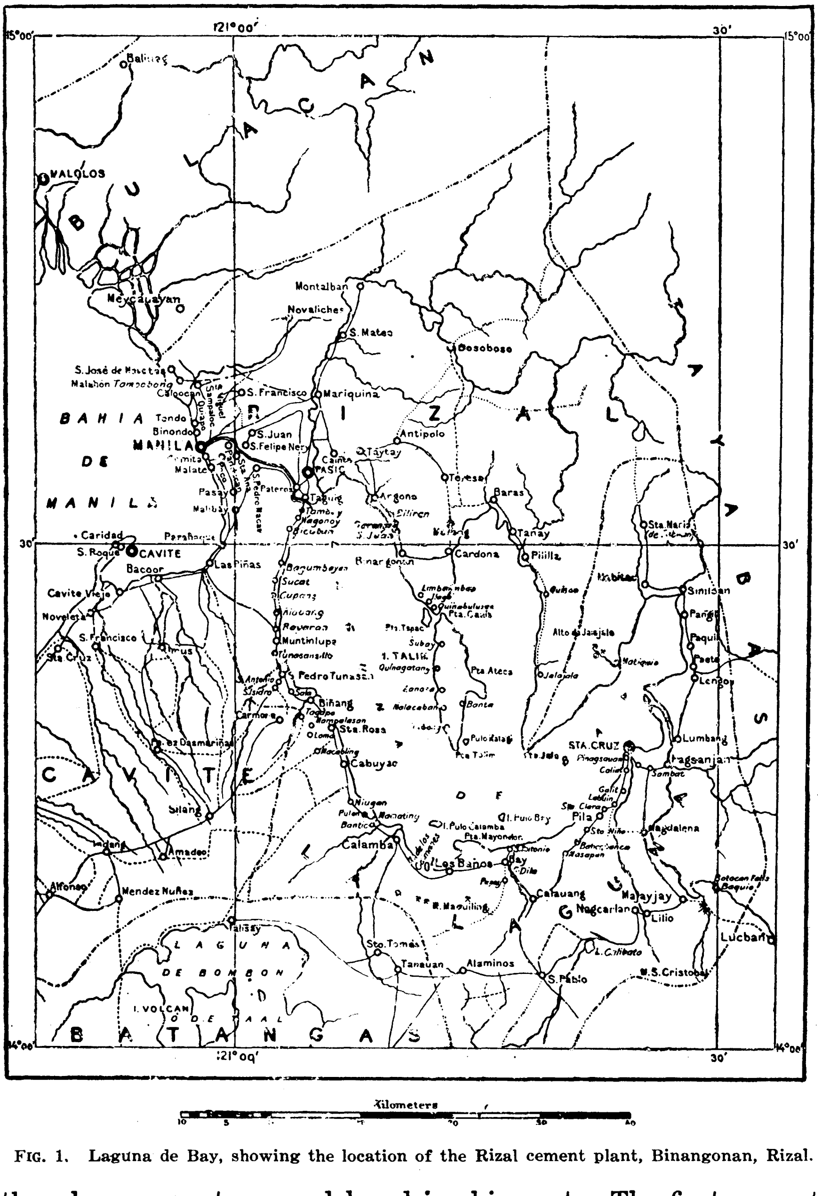

FIG. 1. Laguna de Bay, showing the location of the Rizal cement plant, Binangonan, Rizal.

though some parts were delayed in shipment. The first cement was made in July of the following year—the cement industry had claimed a new territory.

The location of the plant at Binangonan, Rizal, is very favorable. It is on Matiquio Point, on the eastern shore of Laguna de Bay, 35 kilometers from Manila and one hour's ride by automobile over the Manila-Morong road. Direct water transportation to Manila is available via Pasig River. Cascos towed by steam launch make the trip in from four to five hours, taking coal and other supplies to the plant and taking away the finished cement. A narrow-gauge track connects the buildings with the boat landing, and steel dump cars are employed to transport the materials back and forth. There is also regular Yangco boat service, for passengers and light freight, between Manila and Binangonan.

Portland cement is usually defined as the "product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate mixture of properly proportioned argillaceous and calcareous substances, with only such addition subsequent to calcining as may be necessary to control certain properties." This means that to manufacture cement it is necessary to have a supply of materials such that when proportioned according to their chemical analyses, ground, and thoroughly mixed will contain the proper amounts of calcium carbonate, silica, and alumina. The raw mix thus obtained is burned in one of several types of kilns, until it just begins to fuse. During the burning, water, carbon dioxide, and any organic matter present are expelled, and a series of complicated compounds is formed. The resulting clinker is then ground with the addition of a small percentage of some substance that will control the set within certain limits to produce the finished product. Therefore the description of a dry-process cement mill is necessarily the account of quarries, crushers, dryers, storage bins, grinders, and conveyors, which is likely to be of slight interest to any one who is not in some way connected with the industry. And though of course there are no two mills exactly alike, the essential points of the process are so similar that the principal differences of description are concerned with the size, capacity, and arrangement of the various machinery units.

The limestone for the Rizal plant is obtained at the San Guillermo quarry, where it is won by the usual method. It is first blasted with dynamite, then the larger pieces are broken up and loaded into dump cars. The stone is conveyed to a chute, at the bottom of which it is loaded into steel buckets and transported 7 kilometers to the mill by means of an aërial cableway. This is of the two-cable type. The cable that supports the loaded buckets is 3 centimeters in diameter, and the one which supports the returning empty buckets is 2 centimeters. Each bucket is carried by two grooved wheels, which rest on the cable, and has a capacity of 210 kilograms. The power is supplied by an endless 1.3-centimeter cable. The system as at present operated has a maximum daily capacity of 250 tons.

The limestone is a hard stone of high purity and uniformity, averaging between 97 and 98 per cent calcium carbonate. The necessary silica and alumina are obtained principally from volcanic tuff, which is obtained in abundance from a quarry at the site of the plant. It has been found advantageous to use, in addition, some Pasig River sand, which is somewhat higher in silica content. A typical analysis of each of these raw materials is shown in Table I.

The coal and gypsum are at present obtained from Japan. The process of manufacture and the general arrangement of the more important machinery is outlined in fig. 2.

TABLE I.—*Analysis of raw materials.*[a]

[Numbers give percentages.]

	Limestone.	Pasig sand.	Tuff.
Loss on ignition[b]	42.86	3.24	5.77
Silica (SiO_2)	0.68	61.35	53.76
Iron oxide (Fe_2O_3)	0.30	4.82	6.84
Aluminium oxide (Al_2O_3)	0.34	18.46	22.88
Calcium oxide (CaO)	54.72	5.22	5.41
Magnesium oxide (MgO)	0.56	2.72	1.88
Sodium oxide (Na_2O)	0.60	2.26	1.65
Potassium oxide (K_2O)	trace	1.95	1.84
Sulphuric anhydride (SO_3)	trace	trace	trace

[a] Analyzed by Francisco Peña, chemist, Bureau of Science.
[b] Samples were previously dried.

The power plant is equipped with two 600-horsepower compound steam engines of the *Lokomobil* type. The main shaft is so arranged that it may be driven by either or by both engines. The machinery, conveniently located, is driven by the main shaft. The remainder is driven by electric motors. Two 390-kilowatt, 460-volt, alternating-current generators furnish the current.

The calcareous and the siliceous materials are separately run through a jaw crusher, where they are reduced to a maximum size of 5 to 8 centimeters, and are then elevated to storage bins by a bucket conveyor. The crusher has a capacity of 13 tons[2] per hour and requires 20 horsepower. Both bins connect with

[2] Many of the values here given for capacity, fineness of grinding, and the like vary with conditions and are to be considered approximate only.

a hopper scale, where the two classes of material are proportioned on the basis of chemical analyses and mixed. Usually the limestone is very low in moisture content, but the sand averages from 4 to 6 per cent moisture, and the tuff averages from 15 to 17 per cent. It is, therefore, necessary to dry the

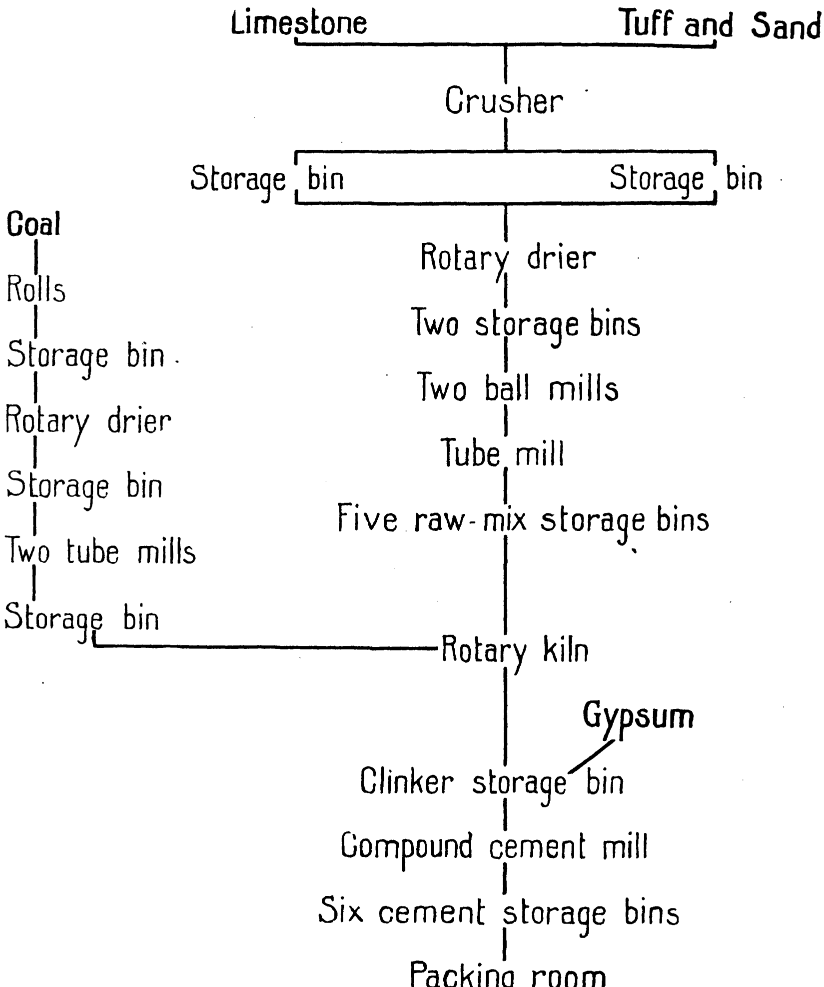

FIG. 2. Outline of the manufacturing process.

mixture before further reducing it in fineness. The drying is accomplished by passing the material through a rotary drier. This is driven at two and one-half revolutions per minute and requires 12 horsepower. It is heated by the combustion gases from a furnace, which utilizes waste wood from the barrel machinery. The capacity of the drier is 10 tons per hour. The material leaving the drier is elevated to storage bins and then enters two ball mills placed in parallel. It is here reduced to a fineness of from 20 to 30 mesh. It next enters the tube mill, which is driven at the rate of 22 revolutions per minute, requiring 250 horsepower, and has a capacity of 10 tons per hour. The material leaving this mill has an average fineness of 80 to 85 cent through a 200-mesh sieve. It is carried to five bins by bucket- and screw-conveyors and is stored, ready for burning.

The rotary kiln is essentially a steel tube, 45 meters long by 2 meters in diameter. It is lined partly by fire bricks and partly by blocks made from cement and cement clinker. It is inclined 6 per cent from the horizontal and requires from 65 to 95 seconds to make one revolution. It has a capacity of about three and one-half tons per hour and requires 20 horsepower. This kiln is of the type generally found in the United States, except it has a greater length than many of them. It has been found that increasing the length of a kiln increases the output and also raises the fuel efficiency. The fuel used is powdered coal, which is blown into the kiln by compressed air. The coal is first crushed by steel rolls. It is then dried in a rotary drier and is passed into two tube mills connected in series. It is here reduced to an average fineness of 97–99 per cent through a 100-mesh sieve. It is afterward lifted to a small steel bin above the kiln.

The raw mix is moistened and is passed into the upper end of the kiln through a water-jacketed pipe. It works its way through the kiln in about one and one-half hours, the temperature gradually rising as it approaches the hottest part of the powdered-coal flame. The operator of the kiln controls the raw mix entering the kiln; the speed of the kiln, the blower, and the coal-feeding device; the air inlet of the blower; and the regulation of the stack draught. It is his duty so to control all of these that the material in the kiln receives the proper degree of burning, with the least expenditure of coal. The hot clinker leaving the kiln drops into a slowly revolving cooler, directly under the kiln, but inclined in the opposite direction. Here it gradually loses heat and at the lower end is further cooled by a jet of water. It emerges sufficiently cool to be stored, in readiness for grinding.

Previous to grinding a small percentage of gypsum (hydrated calcium sulphate) is added to the clinker, for the purpose of retarding the set of the finished cement. This mixture is dumped into a hopper, the top of which is flush with the floor, and is lifted into a small storage bin, which connects with the cement mill. This mill is a long steel tube divided unequally (transversely) into two chambers and lined with iron plates. The first or shorter chamber acts as a ball mill and reduces the material to a fine powder. This passes into the second chamber, where it is reduced to a fineness of about 80 to 85 per cent through a 200-mesh sieve. This is the finished Portland cement. It is stored in bins until it is packed for shipment.

In the United States the general practice is to ship cement in bags of heavy paper or of cotton cloth. The former are usually furnished free by the manufacturer, while for the latter the consumer is charged a few cents per bag, which is refunded when the bags are returned in good condition to the mill. Every bag can be used a number of times, so that the cost of containers for cement is practically negligible. However, in the Philippines atmospheric conditions are not favorable to the use of bags. Though water-proofed bags are from time to time used for a small quantity of Rizal cement, they have never given entire satisfaction. Apparently sufficient moisture penetrates the bag to allow the cement to become caked to some extent. Practically the entire output of the mill is, therefore, shipped in barrels. The company operates its own cooperage shop. This has a capacity of 1,000 barrels per day and is well equipped with modern wood-working machinery. All the parts of the barrel except the hoops are cut directly from the log, and the greater part of the work of assembling is done by machinery.

The present capacity of the cement plant is 500 barrels per day. It was designed for a guaranteed capacity of 1,000 barrels per day, however, and it is only necessary to install another kiln of the same size and make some minor changes to obtain that output.

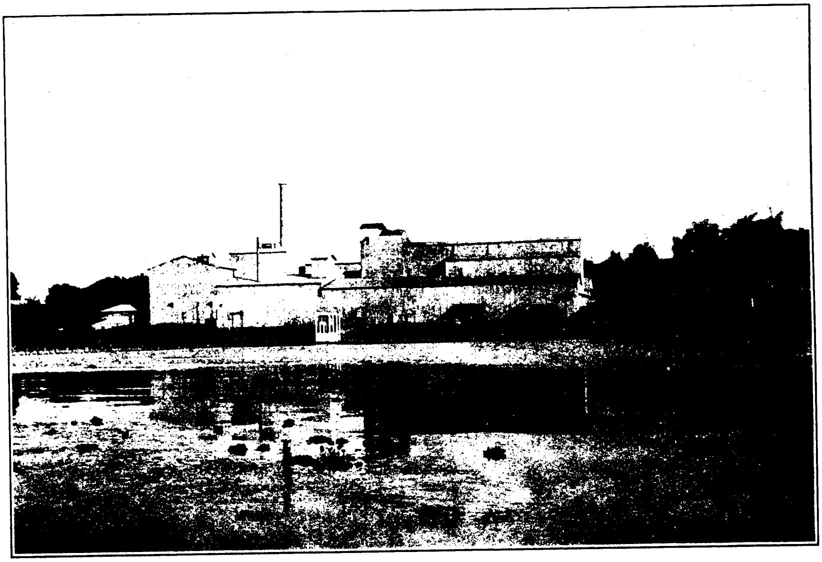

Fig. 1. General view of the Rizal cement plant.

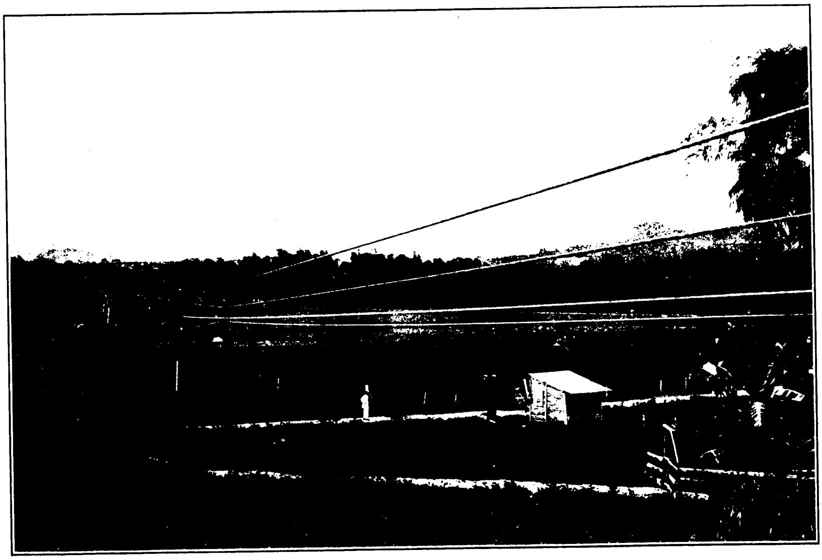

Fig. 2. The cable system employed to transport limestone to the plant.

PLATE II.

Fig. 1. View of power plant.

Fig. 2. Scale used for proportioning the raw materials.

PLATE III.

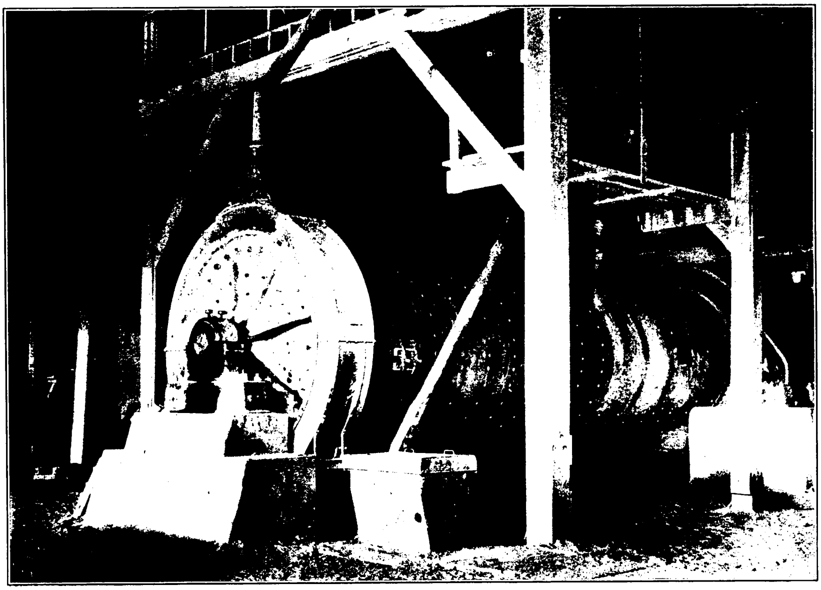

Fig. 1. Tube mill in which raw mix is ground.

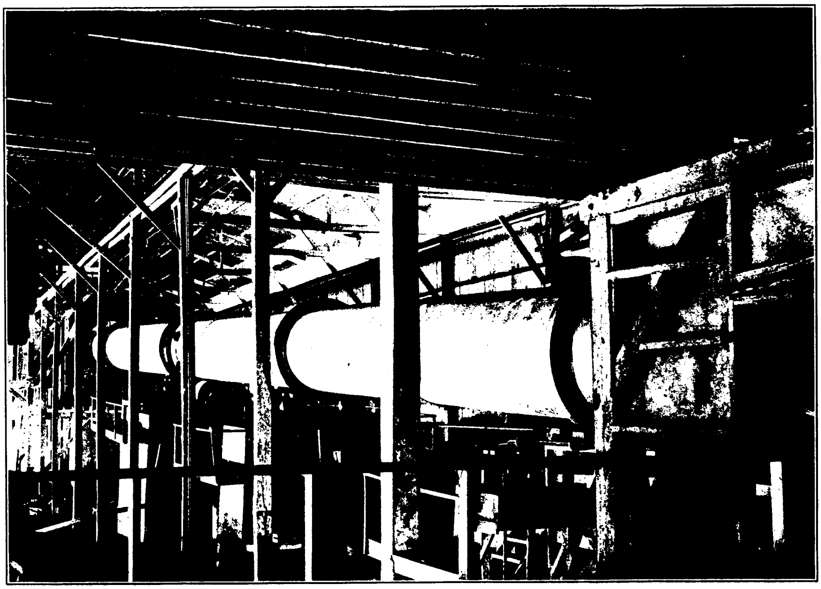

Fig. 2. The rotary kiln.

PLATE IV.

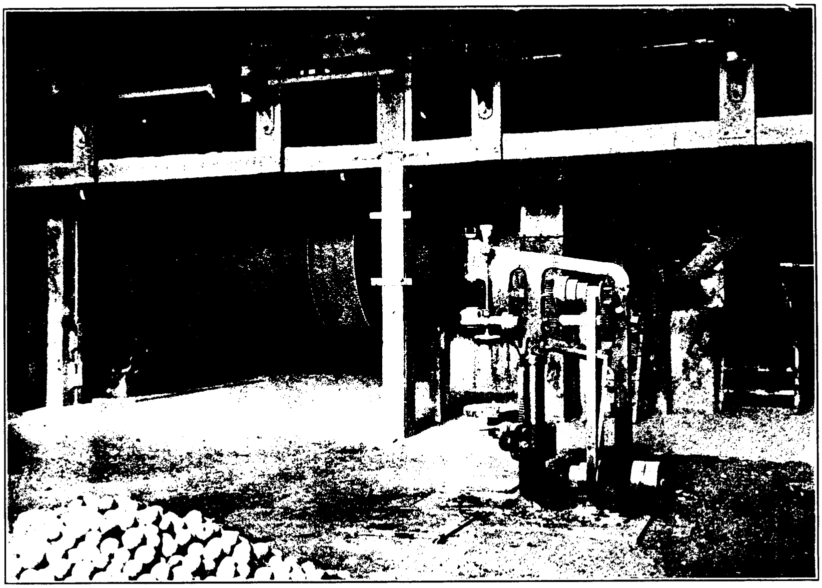

Fig. 1. The compound cement mill.

Fig. 2. A corner of the packing room and warehouse.

PLATE V.

Fig. 1. Interior of the cooperage shop.

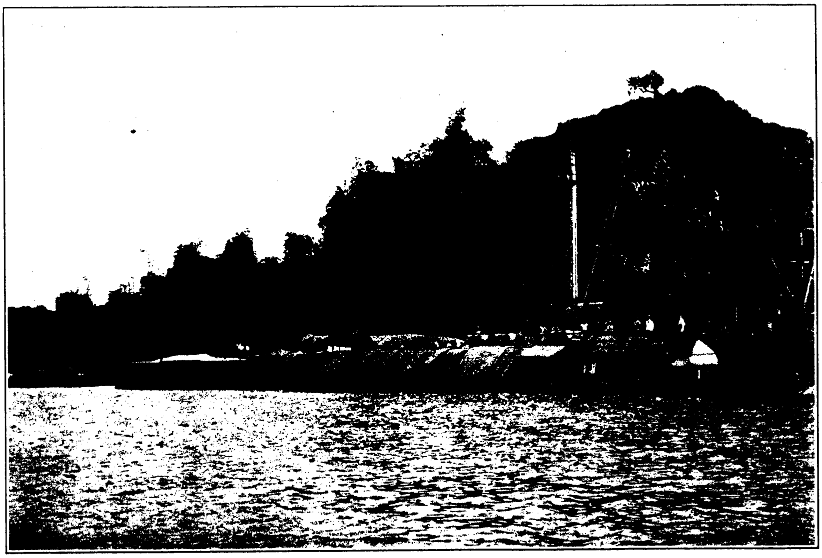

Fig. 2. The boat landing.

PLATE VI.

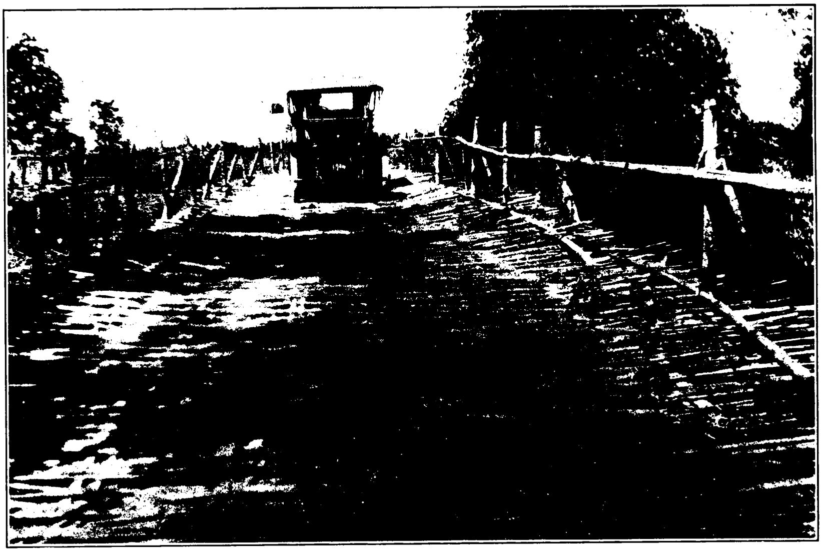

Fig. 1. A bamboo bridge—a rapidly disappearing type—on the Manila-Morong road. 1915.

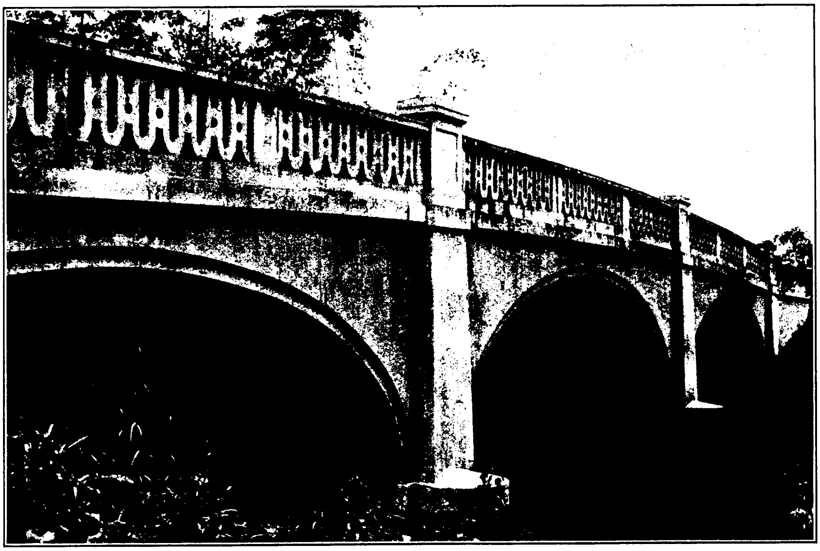

Fig. 2. The bamboo bridge replaced by a modern concrete structure in which Rizal cement was used. This is one of three such bridges in the same locality.

PLATE VII.

GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1917 AND 1918

ISSUED BY THE DIVISION OF MINES
BUREAU OF SCIENCE

MANILA
BUREAU OF PRINTING
1920

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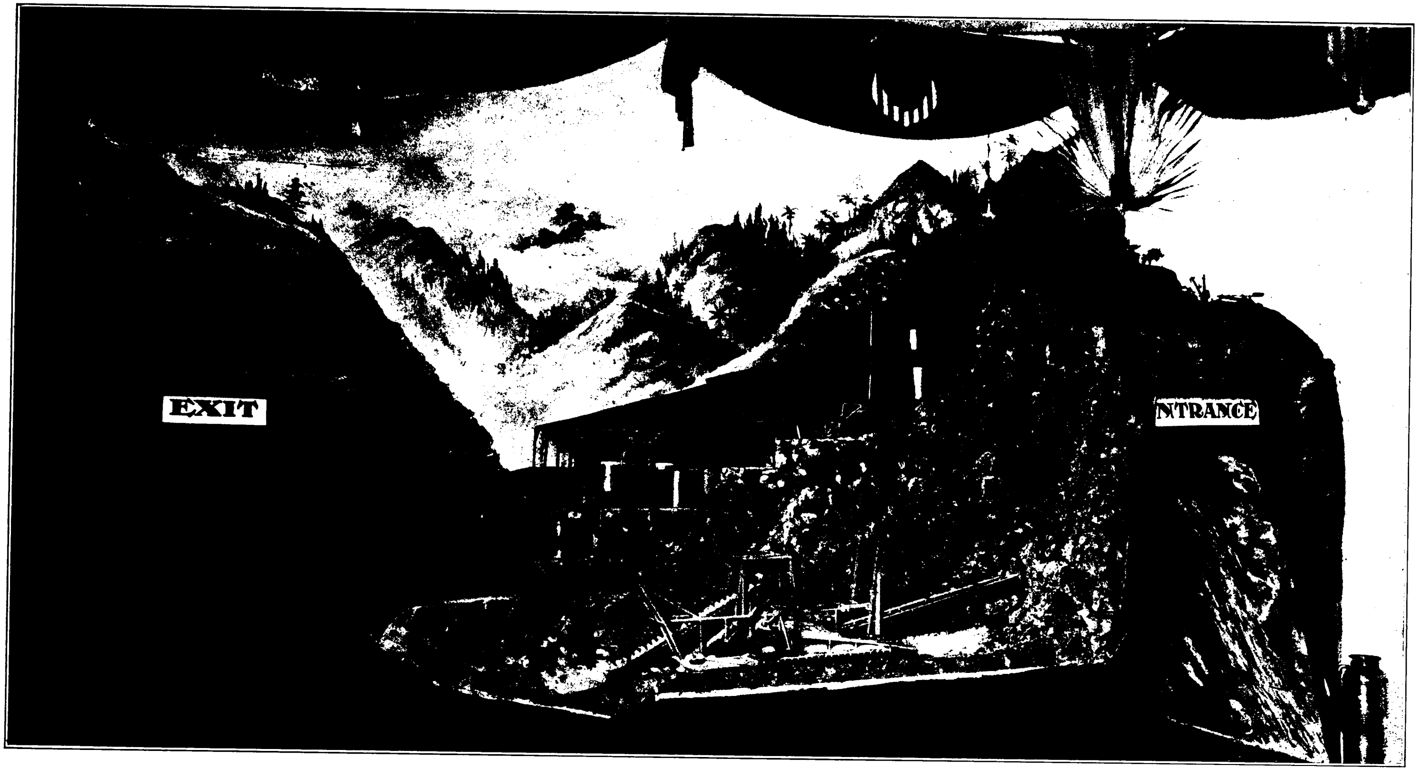

PLATE 1. EXHIBIT OF THE DIVISION OF MINES, BUREAU OF SCIENCE, PHILIPPINE CARNIVAL, FEBRUARY, 1918.

Government of the Philippine Islands
Department of Agriculture and Natural Resources
Bureau of Science

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1917 AND 1918

ISSUED BY THE DIVISION OF MINES
BUREAU OF SCIENCE

MANILA
BUREAU OF PRINTING
1920

THE DIVISION OF MINES OF THE BUREAU OF SCIENCE

ELMER D. MERRILL, B. S., M. S., *Director of the Bureau.*

VICTORIANO ELICAÑO, B. S., *Assistant Chief of the Division, Acting Chief.*

LEOPOLDO A. FAUSTINO, B. E., *Assistant Geologist.*

RAMON ABARQUEZ, B. S. IN PHAR., *Junior Chemist, Assayer.* Absent on Government Scholarship in the United States.

EUSEBIO F. GUTIERREZ, B. S. IN PHAR., *Scientific Assistant, Assistant Assayer.*

PIO MOSKAIRA, *Assistant Draftsman, In charge of Map Section.*

ANTONIO LOREDO, *Junior Preparator.*

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FIG. 1. Asbestos mine in Ilocos Norte. A vein shows at the left of the man in the white shirt.
2. Exterior of asbestos-products factory, Santa Ana, Manila. This picture was taken during an unusual flood.
3. Interior of asbestos-products factory, Santa Ana, Manila.

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1917 AND 1918

INTRODUCTION

By ELMER D. MERRILL

The first issue of this publication on the mineral resources of the Philippine Islands was printed in 1908 covering the preceding year. From that time up to 1916 Mineral Resources was issued annually. Owing to a combination of circumstances the technical staff of the Division of Mines became very much depleted after 1916 so that with the available personnel it was found impossible to carry on the work on the scale of preceding years. Much of the time of the limited technical personnel has been of necessity devoted to matters of a more or less routine nature which has not permitted any large amount of original research and, further, has of necessity limited the work of exploration. It was found impossible to secure the necessary data for the year 1917 for the publication of the number of Mineral Resources which should have been issued in 1918. Under the circumstances it has been considered advisable to make the issue of Mineral Resources cover a biennial period instead of an annual one.

The present issue covers the years 1917 and 1918 and while, owing to unforeseen circumstances, there has been some delay in its preparation, it is felt that a considerable amount of important information is included in the present issue and that the data here presented will be of distinct interest and value to the mining fraternity in the Philippine Islands and elsewhere. The present issue of Mineral Resources is almost wholly the work of Mr. Victoriano Elicaño and Mr. Leopoldo A. Faustino, of the Division of Mines.

REVIEW OF PHILIPPINE MINING ACTIVITIES

By VICTORIANO ELICAÑO

During 1917 gold production in the Philippine Islands amounted to about 366,000 pesos less than in 1916, and the output for 1918 fell about 70,000 pesos below that for 1917. War conditions greatly handicapped the operations of the mining companies; high costs combined with difficulty in obtaining supplies of chemicals, fuel, machinery, and necessary spare parts have caused intermittent shutdowns of dredges and mills in many districts and have delayed development work on several mines and prospects. However, the decline in the production of gold, which in past years has always been taken as an index of mining activities in the Islands, does not mean a drop in interest to push ahead the development of our mineral resources. In fact, the production of coal, sulphur, asbestos, and manganese shows that mining activity was not confined to the development of the gold deposits only.

The considerable advance in the local price for imported coal has given an excellent opportunity to open our coal deposits, and the years 1917 and 1918 were characterized by the resumption of coal mining and by marked increasing production. The Batan field has been reopened and at present leads in production. The Cebu deposits at Uling and Danao are being developed extensively and have largely contributed to the bulk of the home output. A newly organized company and several small operators are working on the Toledo field. The National Coal Company has leased the Compostela mines and has started to open the coal deposits at Sibuguey, Mindanao. Several interisland steamers and launches are now using Philippine coal, the demand for which has so increased as to raise its market value from 20 to 35 pesos the ton. It has been reported lately that Toledo and Cebu coals have commanded a price as high as 37 pesos. From our list of mining operators it may be seen that Cebu is the center of coal-mining activity, and judging by the rapidly increasing production of the district it might be said that it will not be long before the coal-mining industry in the Philippines will compare favorably with gold mining.

New among our industries is asbestos mining and the manufacture of asbestos products. The Ilocos Asbestos Products Company, owning and exploiting the asbestos deposits at Ilocos Norte, has built an experimental plant in Santa Ana and has been successful in turning out a number of asbestos products, which find a ready market in the Philippines. The company is contemplating the early erection of a modern asbestos plant in Manila, thus creating another important manufacturing and mining industry.

Sulphur deposits in the Philippines are small but the high price commanded by this mineral during war times has attracted some capital to sulphur mining. During 1918 a small production was registered, which was exported mostly to Hongkong and Australia. When the order prohibiting exportation of war minerals to foreign countries went into effect, sulphur mining was paralyzed, because of high freight rates and lack of transportation facilities to the United States, which made mining and exportation unprofitable. For similar reasons manganese mining, which in 1916 registered a production of 3,000 tons, had to be stopped. When freight rates come down, it is possible that these two minerals will again occupy a place in our list of mineral products.

The occurrence of commercial quantities of asphaltic materials in Leyte has long been known, and the Leyte Asphalt and Mineral Oil Company, owner of the deposits, has again resumed development work on the property. We are informed that its product is being tried out on some of the Government roads in the southern islands. The Tayabas and Mindanao oil fields are at present being explored by representatives of American companies, and it is hoped that something promising will result from their investigations.

Iron is another mineral product of the Philippines which will gain in importance in the near future. The Japanese concern working the Calambayanga deposits will soon be ready to make a shipment of iron ores to Japan. A newly organized company is contemplating the exploitation of the recently discovered deposits in Bukidnon, Mindanao. Another local company will soon start operating a small blast furnace in Bataan Province, to smelt magnetite sand, an abundance of which is found naturally concentrated along the Bataan beach bordering Manila and Mariveles Bays. The Bulacan deposits continue their small production and the use of the native furnaces is still practiced.

Several national mining companies have been created by the Philippine Government. The National Coal Company, as has been stated, has already started work on the Compostela and Sibuguey coal deposits. The National Iron Company was created to work the immense iron-ore deposits reserved by the Government in Surigao, and to manufacture iron and steel therefrom. The National Cement Campany will probably exploit the extensive deposit of raw cement materials found in the vicinity of Naga, Cebu, and will be engaged in the manufacture of Portland cement. The National Development Company will engage in commercial, industrial, and other enterprises that may be necessary or contributory to the economic development of the country or important in the public interest. This company with its wide scope for action will undoubtedly devote part of its activities to the development of our mineral resources.

The present known mining fields or districts are only partially developed, and the whole Archipelago is still unexplored; it is hoped that this vast industrial development policy of the Government will be followed by local capital and that it will serve as an incentive to foreign investors.

MINERAL PRODUCTION OF THE PHILIPPINE ISLANDS IN 1917 AND 1918

By LEOPOLDO A. FAUSTINO

The publication of mineral production of the Philippine Islands began in 1908 with the first issue of Mineral Resources, and tabulated statistics of production have appeared in every issue since. These statistics show in a general way the growth of our mineral industry. Some of the figures were compiled from statements and reports, while a few were estimated. Estimates have been made where the production could not have been arrived at in any other way. In a country like the Philippines where the mineral industry is still in its infancy gathering data for mineral statistics is not an easy matter. There is always the tendency to withhold statistical information. Better figures could have been available, but as we have to depend on the good will of the producers for statements and reports in the collection of our data, we believe that our efforts have met with success.

This issue of statistical production probably approaches very nearly the exact figures, which condition may be explained by the fact that nearly all the producers have been willing to report their annual production. All the gold producers promptly sent in their reports; and the gold production for 1917 and 1918 is represented by exact figures. The iron produced is undoubtedly more than that shown in the table. There are a few producers who failed to render any report regarding their mines, in spite of the fact that the Bureau of Science has written them several letters and has spent considerable time in correspondence asking for their production figures. Instances like this are to be regretted, because correct figures could have been available except for the fact that one or two producers would not see the value of reliable statistics. Act 2719 of the Philippine Legislature requires all coal operators to render regular reports to the Bureau of Science, and the coal production is calculated from figures given in those reports. The figures for asbestos, sulphur, and manganese ore production were given by the owners of the mines and should be correct. The manufacture of clay products, the making of lime, and the production of salt are household industries, and some means will yet have to be devised to keep track of the output. What has been done is that reported activities in the different districts were compared with those of previous years. The figures for these household industries are therefore approximations and estimates. Increased activity is taken to mean increased production and vice versa. It will be noted that the production of these mineral products has been increasing every year. The probabilities are that the activities noted are not so much in the amount of the products actually produced as in the money value recovered from their sale. The figures for sand and gravel and stone production are estimates, based upon the reports of the district engineers of the Bureau of Public Works, which is the largest single producer, and upon the noted activities in the building and construction program of the Department Quartermaster, United States Army, Manila, the Manila Railway Company, and the Manila Electric Railroad and Light Company. Other companies and individuals in Manila and Baguio and in the provinces were also considered, particularly the dredges and quarries which have been more or less active during the year. The apparent decrease in the number of liters of mineral waters produced is due to the fact that only strictly mineral water is considered. Heretofore artesian water has been included in the figures for mineral waters.

It is customary to compare each year's production with that of other years, and on account of the different units of measurement employed, the comparison must necessarily be in the value. In line with this established custom, Table 3 is herein given.

The Bureau of Science wishes to acknowledge with thanks the reports submitted by mining companies and individuals, the data given by the district engineers of the Bureau of Public Works, and the valuable information regarding the mining industry received from insular, provincial, and municipal officials. The coöperation of all those connected with the industry has made the compilation of our statistics possible. It is hoped that requests for statistical figures for 1919 will be answered in the same spirit; their receipt will be promptly acknowledged. Statistics of mineral production will then be made available to the public in sufficient time to be of value to those interested in the mining industry.

STATISTICS OF MINERAL PRODUCTION IN THE PHILIPPINE ISLANDS IN 1917 AND 1918

By LEOPOLDO A. FAUSTINO

TABLE 1.—*Mineral products of the Philippine Islands for the calendar years 1917 and 1918.*

Product.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
Metallic:		*Pesos.* [a]		*Pesos.* [a]
Iron ---- metric tons	66	17,936	70	24,983
Silver [b] ---- fine grams	81,578	4,895	128,974	8,306
Gold ---- do	1,990,463	2,645,784	1,937,941	2,575,970
Manganese ore ---- metric tons	----	----	650	9,000
Total value of metallic	----	2,668,615	----	2,618,259
Nonmetallic:				
Asbestos ---- metric tons	----	----	70	5,250
Coal ---- do	5,748	141,425	15,603	385,400
Clay products [c]	----	900,000	----	910,000
Lime [c] ---- metric tons	14,000	270,000	15,000	375,000
Sand and gravel [c] ---- cubic meters	525,672	788,508	483,061	724,591
Stone [c] ---- do	232,196	417,952	307,619	553,714
Salt [c] ---- metric tons	26,000	780,000	30,000	900,000
Sulphur ---- do	----	----	72	11,140
Mineral waters ---- liters	255,800	63,950	200,000	50,000
Total value of nonmetallic	----	3,361,835	----	3,915,095
Grand total	----	6,030,450	----	6,533,354

[a] One peso Philippine currency equals 100 centavos, equals 50 cents United States currency.
[b] No silver is mined separately, but a small amount is alloyed with the gold.
[c] Estimated production.

TABLE 2.—*Philippine gold production by districts for 1917 and 1918.*

[One gram fine gold=1.32923 pesos.]

Districts.	1917		1918	
	Quantity.	Value.	Quantity.	Value.
	Fine grams	*Pesos.*	*Fine grams*	*Pesos.*
Ambos Camarines	765,327	1,017,296	425,431	565,496
Masbate	703,187	934,697	802,551	1,066,775
Mountain Province	521,380	693,034	709,633	943,265
Miscellaneous	569	757	326	434
Total	1,990,463	2,645,784	1,937,941	2,575,970

Table 3.—*Total value of mineral products of the Philippine Islands from 1907 to 1918.*

Year.	Metallic.	Non-metallic.	Total.
	Pesos.	*Pesos.*	*Pesos.*
1907	207, 293	26, 799	234, 092
1908	454, 543	928, 772	1, 383, 315
1909	541, 892	1, 781, 475	2, 323, 367
1910	331, 291	1, 768, 286	2, 099, 577
1911	413, 271	2, 413, 139	2, 826, 410
1912	1, 198, 360	2, 315, 385	3, 513, 745
1913	1, 801, 195	2, 143, 386	3, 944, 581
1914	2, 415, 419	2, 197, 972	4, 613, 391
1915	2, 671, 887	2, 195, 699	4, 867, 586
1916	3, 068, 195	2, 596, 065	5, 664, 260
1917	2, 668, 615	3, 361, 835	6, 030, 450
1918	2, 618, 259	3, 915, 095	6, 533, 354
Grand total	18, 390, 220	25, 643, 908	44, 034, 128

PHILIPPINE GOLD MINING

By VICTORIANO ELICAÑO

CAMARINES DISTRICT

This district comprises practically the Mambulao-Paracale distict of Camarines. In quantity of production, it occupied first place in 1917, but in 1918 it was only third. There were eight dredges working on the district in 1917, while during 1918 only six contributed to the production.

The Gumaus dredge.—This dredge was working in the interior of Gumaus Bay in the early part of 1917, and its operations were very successful in every way. It was the largest producing dredge of its time. Toward the end of 1917, having completed dredging the ground where it was built and operated, the dredge was to be transferred to Malaguit River to continue operations there, and while in Gumaus Bay awaiting the steamer to tow it to its new place it was overtaken and sunk in the bay by the typhoon of December, 1917. The destruction was complete as the dredge had to be dismantled and the machinery taken ashore.

The Philippine Dredges Limited.—This company is operating two dredges, and manages the operations of two others belonging to the Paracale Bucket Dredging Limited. All four dredges have been working on Paracale River, and have turned out most of the output of the district. Toward the end of 1918, however, the two dredges of the Paracale Bucket Dredging Limited stopped operations, and they are now being dismantled. The management informed us that high cost of operation, difficulty in obtaining spare parts, and other difficulties are largely responsible for the decision of the home office.

The Malaguit dredge.—This dredge was formerly operated by the Malaguit Dredging Company, but lately Messrs. Jumper and MacDonald acquired the property and they are going to operate the dredge. Repairs had to be made on the boilers and the hull. The intermittent operation of this dredge was due to the poor condition of the boilers.

The Maximelo dredge.—This is working on a river tributary to the Paracale. Its operation is intermittent and the production small. It was operated by Mr. Lafferty, but after he died his brother leased the dredge to Mr. Reed who, we are informed, suffered financial loss in its operation. Messrs. Harry Hardman and E. W. Edie purchased the interest of the late Mr. Lafferty and will continue work.

The Mambulao dredge.—This dredge, recently built by the Mambulao Placer Company, is now working in Bulalacao Bay. It started operations in Mambulao Bay, but the ground was too poor to pay the cost of operations, and it was decided to transfer the dredge to its present location. On making the transfer and while the dredge was still out in Bulalacao Bay a typhoon sank it; luckily, it was not completely destroyed. After the repairs and changes that had to be made the dredge started work on Bulalacao Creek with satisfactory results.

The Paracale Venture Corporation.—The work on the property of this company has been resumed. The plan is to work the placer deposits under the coconut grove by tunneling along the bedrock. The ground is supposedly an old river channel about 20 meters deep. At present the work consists only in repairing and extending the shaft which was started about two years ago.

The San Mauricio mine.—Some development work was done lately on this property, but it has been again abandoned. The shaft has totally caved in, and parts of the newly driven tunnels are also falling down. We have been informed that the Philippine Exploration Company, present owner of the mine, will resume work on the property some time this year.

The Maliit mine.—The property of Mr. Cavender at Maliit has been leased to Messrs. Muller and Moisan. Mr. Muller, who is in charge of the work, has made some repairs on the mill, which is equipped with one chain crusher, ten stamps and amalgamating plates. Power is supplied by a steam engine and boiler of marine type. The plan outlined by Mr. Muller is to mine the outcrop of one of their big lodes and put it through the mill and, at the same time, to reopen some of the old tunnels in order to continue the development of the mine.

MASBATE DISTRICT

In 1917 this district occupied second place in the production of gold, but in 1918 it was the leading producer. The Keystone mine and mill were shut down in the latter part of 1916, and both the Colorado and Syndicate have added new machinery and introduced new improvements in their mills, all of which contributed to a decrease in the production of the district as compared with that of 1916. Two newly opened camps, the Balete and Napuañgan, have added their bit of production to the bulk of 1918.

The Colorado Mining Company.—The low production reported by this company in the past two years has been due to the remodeling of their cyanide mill and to the installation of their new 500-horsepower McIntosh Leymour Diesel engine, which recently arrived from San Francisco, where it was exhibited at the Panama Exposition. We are also informed that the mill is being run more extensively on low-grade ore. Of the twenty stamps with which the mill is equipped only ten are being operated, as the ore fines are sent directly to a ball mill, which was made by cutting one of the tube mills into halves. The innovation is reported to give satisfactory results as to economy in power and increase in capacity. With these rearrangements and new improvements it is expected that the company will again occupy the important place it formerly held in gold production.

The Colorado mine is at present the most extensively developed in the Islands. Two new adits have been driven to cut the lode at lower levels, and all underground developments are being extended toward the old Keystone properties, the company having acquired some of the adjoining claims.

The Syndicate Mining Company.—The Syndicate Mining Company has reported low production for the past two years. It seems that the mill has been operated mostly on low-grade ore due to difficulties encountered by the former management in bringing the high-grade ore to the mill. Frequent shut-downs, due to power troubles and to the installation of new engines and other improvements in the mill, were also partly responsible for the decrease in production. However, under the present management of Mr. Evans, and with the coöperation of Mr. Carpenter and Mr. Thomas, mill and mine superintendents, respectively, the output has been brought back to its former normal quantity, and judging from the mill run of the past six months the production of 1919 will be double that of the preceding year.

An interesting experiment in combining amalgamation and cyanidation is now being conducted by the management, and we are awaiting the final results with keen interest. So far, the experiment seems to be a success, and I am inclined to believe that it will be an excellent and economical innovation in the present practice of the district, which is to use either one or the other of the two methods.

Other improvements considered by the management are the installation of a set of rolls, one or two more tanks, and another filter unit. At present the mill is treating only 110 tons daily, although its power equipment is able to handle as much as 150 tons; but this could only be attained with the addition of the improvements mentioned above.

The development of the mine has been carried on intensively and extensively. It is reported that there is enough ore blocked out to keep the mill going for a couple of years with its present capacity and average grade of ore.

The Old Keystone.—Part of the Keystone properties has been acquired by the Colorado Mining Company; the greater part, however, has been restaked by Mr. Gerringer and other local prospectors. Mr. Pablo de la Rosa has an option for the purchase of the claims of Mr. Gerringer and associates, the stipulation of the contract being that he perform a certain amount of development work on the property. At the time of our visit, however, no additional development was observed.

The Buyuan claims.—During 1917 great activities were shown toward development of the prospects at Buyuan, but lack of capital and failure to cut the vein in some of the tunnels driven at lower levels caused the temporary abandonment of the claims. There are numerous faults in this district and, from what could be observed, the tunnels have been driven in wrong directions.

The Lawa-an property.—The development of this property has progressed very little, although with its 5-stamp mill it has contributed a little in the gold production of the district. Mr. Schober operated the mill during 1917 and part of 1918. Mr. Schwab continued its operation in 1918 and at the end of the year leased the ground to Mr. Rutherford, who is at present working the mill. No systematic development is being followed, the ore fed to the mill being obtained at random from outcrops and places near the mill.

The Balete property.—This property is owned by the Balete Mining Syndicate, financed mostly with local capital. The owners have bought and installed the 6 individual-mortar stamps which were bought by the Keystone from the Bua Mining Company, and have kept up the development of the property with the proceeds from the amalgamation of their high-grade ore.

The Napuañgan property.—When this property was opened early in 1917, it promised to be a continuous producer; but faulty management spoiled the bright expectations of the owners and checked the progress of its development. With the showing of good values on the surface, economy in operation was rather overlooked, which resulted in the paralyzation of the workings when it was discovered later that the values were somewhat irregular and that extraction was not sufficient to meet expenses of operation and outstanding obligations of the owners.

It is rumored that a company is being organized to purchase the Balete and Napuañgan properties to develop them in the proper way. If this is done, there is no doubt that Masbate will have another big producer in the future, as the properties are very rich and promising.

MOUNTAIN PROVINCE DISTRICT

This district made a record in 1918 as having the largest independent gold producer in the Philippines, the Benguet Consolidated Mining Company. It has also been reported that negotiations are under way for the construction of mills at the Acupan and Demonstration mines which will eventually place this district foremost among Philippine gold-mining regions.

The Benguet Consolidated Mining Company.—This company is the largest operator in the district and in fact is the only one operating on a large scale. Its mill equipment has been described in the Mineral Resources of 1914 by Mr. C. M. Eye, the engineer who designed, erected, and later superintended the operation of the mill. It is to the untiring efforts, experience, and ability of Mr. Eye, and the brilliant management of Mr. Beam, that the company owes its present success.

The daily capacity of the mill is from 50 to 60 tons, but during the dry season the capacity has been cut down to 30 tons for lack of water power. A careful selection of ore had to be made in order to offset the low capacity of the mill and only high-grade ores were treated. At the time of our visit, the construction of their new hydroelectric power plant was progressing very rapidly, and we were informed that this power plant No. 2, which is a duplicate of No. 1, will be operating within two months. The new plant is located farther below Antamok River and when in operation both power plants will furnish the mill with enough power even during the dry season. The company is also contemplating the enlargement of its present mill by the addition of another crusher, revolving trommel, tube mill, leaching tanks, and filters, the purpose being to increase the capacity to about 120 or 150 tons.

The underground work at the mine is proceeding steadily, especially at level "B," where high-grade ore has been encountered. Enough ore has been blocked out to keep the mill in operation for the next two or three years. The company has started the sinking of a shaft that is calculated to cut the vein at a depth of 600 feet. The hoisting machinery is already in place, and with the arrival of the motor and the completion of the new power plant operations on a bigger scale will be started.

The company has acquired a few adjoining claims of the Bua and Fienza groups, in order to protect its water rights, and has also taken an option on the Camote claims which are in the vicinity of their new power plant.

Demonstration mine.—This mine is located on the Copper King group, and its workings are under the management of Mr. H. P. Whitmarsh. There are two veins on the property; one is a calcite-quartz-manganese vein, and the other is a refractory vein composed mainly of copper, lead and zinc, and sulphides, but carrying values in gold and silver. Development has been done exclusively on the first vein, which varies both in width and value. The general average, however, is said to be high. Four adits at different levels have been driven into the vein following the strike, and ore calculated to amount to about 100,000 tons has been blocked.

A mill, equipped with a 5-stamp battery and two amalgamating plates, was built on the property to test the ore. The mill has produced about 35,000 pesos from ores that came from the development workings. The tailings were saved for future cyanide treatment and were stored in settling ponds dug out and built along the sides of the hills. Operation of the mill started in 1917 and continued until the latter part of 1918, when it was shut down on account of the low extraction, and the considerable loss of tailings that were washed down by rains.

At present negotiations are on foot with some Hongkong capitalists who have been interested in the property and are willing to finance the company. The property and the workings are now being surveyed and examined in order to facilitate more systematic development and blocking of the vein. When the survey is completed it is expected that the erection of a 150-ton cyanide mill will be started.

The Acupan Mining Company.—This property has been described in the Mineral Resources for 1915. The 3-stamp mill which was built in 1915 continued operations in 1916 but was shut down in the early part of 1917. The development has continued under the supervision of Mr. T. Philips who has driven several tunnels at different levels showing fairly well the continuity of the vein. The mine has been recently examined, but we were unable to obtain any figure on the average assay values of the ore. The mine will, I believe, be further developed before the construction of the proposed cyanide mill.

Headwaters mine.—At the expiration of the lease of Mr. L. O. Hibbard this mine was leased to Messrs. Hagen and Reynolds. Some repairs had to be made on the mill and pipe line, and the mine had to be put in condition so that it might produce sufficient ore to supply the required tonnage of the mill. Operations were started in 1917 and the production of the last two years was about 27,000 pesos. Lately the partnership of Hagen and Reynolds was dissolved, and Mr. Hagen has taken over the property. He informed us that he is interesting Hongkong capital to purchase the mine and to develop it more systematically.

The Ascension claims.—Mr. Calvin Horr continues to operate his small mill on this property with selected ore from the mine. His operations are intermittent, and his production is small.

The Palidan properties.—The Palidan mines at Suyoc have been leased to Mr. Hora, who has been working on them for the last two years, but with no apparent success, and he expects to give up his lease soon. In 1917 he drove a tunnel about 300 feet on the property, but during the rainy season of 1918 the workings collapsed and were lost. He has driven two new tunnels where he is able to take a few tons of the soft ore every day and treat them in a sluice box.

Mr. Gillies continues working on his property adjoining the Palidan. He has driven a tunnel along with the vein and is taking enough ore to work his arrastre mill twenty-four hours a day. He is producing enough to pay all expenses and keep up the development of his copper prospects below his gold claim.

OTHER DISTRICTS

Mr. Geo. Mentzer has been operating his stamp mill intermittently at Binalonan, Pangasinan. He has interested some Manila capitalists who have decided to develop the property on a larger scale and put it in shape for a larger mill.

Mr. A. Villager has discontinued the development of the property in Panaon Island. The mine was examined in 1917, and it is supposed that the values obtained did not warrant further expenses.

The Cansuran Placer Mining Company stopped operations altogether in Surigao. Mr. S. E. Rowell, whose Butuan River claims adjoin the Cansuran, is interesting his company to buy the Cansuran machinery and install it on his property.

The Surigao Mining Company has also given up its mining work at Cansuran.

A party of Paracale mining people tested several placer grounds in Mindanao. The results of the tests, we are told, are very satisfactory, but the conditions imposed by the owners of the properties were not acceptable to the dredging people.

The Umeari dredge at Umeari River discontinued operations and is awaiting orders from its home office at Australia. It was reported lately that some Hongkong capitalists are negotiating the purchase of the dredge.

The properties on Alabat Island, near Sangirin, have been abandoned, and there is no report of a future plan for resuming work on them.

IRON AND OTHER METALLIC MINERALS

By VICTORIANO ELICAÑO

IRON

The production of iron from the Bulacan districts and its use in the form of plow points and shares, have continued steadily. Since the importation of light American plows began, the production of native agricultural implements has fallen off in quantity; not so, however, in price. The old native method of smelting is still used, and the difficulty now encountered by the smelters in obtaining a good fuel supply near the mines is another reason for the decreasing production. The smelting plants, according to former practice, are moved from place to place to be near the charcoal supply. At present there are plant sites 8 or 10 kilometers from the source of the ore, and about 30 or 40 kilometers from the town of Angat, Bulacan, the principal distributing center of the smelters' products. It is partly for these reasons that small smelters could not keep up with the industry, which in the last two years has been greatly handicapped by the increasing cost of labor.

The curtailment of pig iron importation practically stopped the manufacture of agricultural and household implements in Manila by the Chinese, who still continue these operations intermittently by using scrap iron. The Chinese products, however, do not command as high a price as do those made from the iron produced by the Bulacan smelters.

With the shortage of scrap and pig iron, greatly needed in our local foundries, attention was directed to the possibility of producing gray iron from Philippine ores without entailing the need for large capital. Improvement of our native furnaces was naturally suggested as a possible solution. The Bureau of Science became interested in the matter, but owing to the small amount of funds available for the experiments the coöperation of the Bulacan smelters was sought. After eliminating countless difficulties in the transaction, the consent of Mr. Matias Fernando, a mine owner and smelter of Angat, was finally obtained, and the experiments were started in his furnaces by Dr. T. Dar Juan, Mr. F. D. Reyes, and myself.

Without making any change in the construction of the furnace, some preliminary experiments were conducted, just to demonstrate to the owner the advisability of, and the economy that would result from, the introduction of a few changes in the old native process and in furnace construction. It was foreseen that gray iron could never be produced unless some change were made in the furnace; but to take such a radical step would be to break the agreement with the owner of the plant. Consequently a mechanical blower was first installed to substitute the native hand blower. With the increase and easy regulation of blast, the output of the furnace was practically doubled. A similar result was obtained by increasing the proportion of ore to fuel in the charge. For the same weight of iron reduced, the amount of fuel consumed was half that regularly required when using the native blower. Up to this point, all the improvements introduced have practically demonstrated their economical advantage, with one exception; and that is, when too high a temperature was attained in the furnace the ore came down so fast that some of it remained unreduced. This fact practically showed that gray iron could not be produced without making some change in the design of the furnace. It is regretted that funds were not available to undertake such a small change as was planned, and the experiments could not be carried to a successful termination.

The Bureau of Science coöperated also with Mr. M. E. Heacock in his attempts to smelt ore from the Calambayanga deposits. The experiments were carried out in a cupola furnace here in Manila. They were successful in the way a product was obtained; which, like that from Bulacan furnaces, was also white iron. Once again was demonstrated the necessity of increasing the height of the furnace to obtain higher temperature. Mr. Heacock continued his experiments in the Army shops at Corregidor, and has made use of magnetite sand instead of the hematite from the Calambayanga deposit. It has been reported that his experiments were successful, he having obtained a product suitable for regular foundry work. He has organized a company, The Manila Iron and Steel Company, which will erect a small blast furnace in Bataan and will exploit the deposit of magnetite sand which is found naturally concentrated along Limay and Mariveles beach bordering Manila Bay. Mr. Heacock also invented a briquetting machine to briquette the sand and will make use of a clay found in the vicinity of the sand deposit as binder. Good results have been obtained in other countries from furnaces such as Mr. Heacock intends to build, and we entertain all hopes for his success.

Exploitation of the iron deposits on Calambayangȧ Island has commenced. This deposit has been fully described by Mr. W. E. Pratt in the Philippine Journal of Science. The Philippine Mining and Industrial Company, a Japanese concern, recently bought the property from Mr. A. E. Cavender, and has started intensive exploitation. At the time of our visit we had the pleasure of seeing the completion of a wooden pier from the beach to the deep water's edge. It is about 40 meters long, and tracks were already being laid for a narrow-gauge railroad which will connect the pier with the working places around the Islands. We were informed by the superintendent that the company is employing, on the average, about 300 men daily, and is mining from 100 to 150 tons of ore per day. The Camarines miners are used to dredging, and are just beginning to receive their first training in lode mining, which accounts for the low efficiency of Filipino labor complained of by the management. It is suggested, however, that if deeper holes were drilled into the ore mass before blasting, more satisfactory results would be obtained. Ordinary bench-quarrying methods are used, the ore being delivered by means of wooden chutes to the lower benches, where it is loaded in hand-cars to be dumped into scows at the pier. The ore will be shipped directly from the mine to Japan, in boats especially chartered by the company, and will be smelted there, as the company does not contemplate building a blast furnace in the Philippines.

The National Iron Company has been created by the Government to exploit the iron deposits of Surigao. The company will engage in the manufacture of iron and steel, but so far nothing has been heard concerning its organization and future plans.

The Vamenta Chaves Mining Company has also been organized recently to exploit the newly discovered iron deposits in Bukidnon, Mindanao. The ore is practically pure magnetite, and the deposit is claimed to be very extensive. No examination of the deposit has as yet been made by the Bureau of Science.

LEAD AND ZINC

The development of the lead and zinc deposits in Marinduque Island has been retarded on account of war conditions. The deposits are owned by the Marinduque Mining Company. Representatives of the Division of Mines were unable to visit this mining district, but I am inserting the following brief description of the property which, on my request, has been kindly furnished by Mr. E. E. Calvin, the secretary-treasurer of the company:

"The 15 claims in this group were located during the year 1916.

"They are located on the East side of the Island of Marinduque, about half way between Santa Cruz and Torrejos and are about 3 kilometers from Salamaga Bay.

"Development work has been done to the extent of 20,000 pesos in the past two years.

"The veins are true fissure-veins, and are from 4 to 10 feet wide, carrying lead and zinc in about equal proportion, an average of 6 per cent lead and 6 per cent zinc. Rich ores are found in many places, some running as high as 60 per cent lead and others as high as 45 per cent zinc. Some of the veins carry copper to the amount of 2 to 3 per cent.

"The ores are galena and sphalerite embedded in quartz, the country rock is andesite. The main veins cross four rivers, and the ores are found in solid formation in river beds; good backs, in some cases 500 feet, are to be had between the rivers.

"Testing was done in 1918, a 12 per cent lead and zinc ore was jigged in a 20" $\times$ 20" single hand jig and a 60 per cent lead concentrate and a 45 per cent zinc concentrate were obtained. The ore was crushed by a 500 pound dolly bar spring pole lift.

"The concentrates with some picked ore were smelted in an open hearth furnace; a small amount of pig was obtained. The lead concentrates carried 6 to 8 per cent zinc, which made smelting very difficult. With a modern concentrating plant, cleaner concentrates can be obtained, which can be easily smelted in the open hearth furnace. Charcoal made at the mine was used.

"Plenty of water can be had at mill site for milling purposes, but not for power. Mining timbers and fire-wood are plentiful near the mine."

Development of the property is again under way, and with the termination of the war it is expected that the company will be able to carry out its plan of building a small concentrating plant in Marinduque. The concentrates will not, I believe, be smelted in the Philippines, but will be shipped to Japan or the United States.

MANGANESE

The increased price of manganese ore during the war caused a rush for further search of new deposits of this ore throughout the Archipelago. Ilocos Norte, Pangasinan, and Masbate, which are districts known to contain manganese deposits, have again been prospected and new locations and relocations of manganese claims have been made there. However, the prohibition against exporting war minerals to foreign countries and the excessive freight rates to the United States seem to have paralyzed the development of the industry. Only 650 tons of ore, valued at 9,000 pesos have been reported as the production from Ilocos Norte during 1918. The ore, which was to be used by a local firm in the manufacture of dry batteries, is still at the mine pile awaiting transportation. In 1916, 3,000 tons were shipped to Japan, but a misunderstanding between the producer and the purchasing Japanese firm resulted, I believe, in financial loss to the former, for no further shipment was made.

COPPER

The Mancayan copper deposits have been taken up and are being developed by local capital. Mr. V. E. Lednicky, formerly chief of the Division of Mines, is in charge of the workings and has informed us that the erection of a concentrating mill is being contemplated.

Mr. Gillies has resumed the development of his copper claims at Suyoc.

Mr. Feliciano Nable, a local mining engineer, has taken charge of the development of the Pangasinan copper deposits at Salasa, and started experiments in smelting some picked, high-grade ore, using a furnace of the Bulacan iron type. It is assumed that the experiments were unsuccessful, for no further development of the process has been heard of.

MERCURY

A beautiful specimen of cinnabar, claimed to have been found at Coron, Busuanga, Palawan Province, was brought to our office for identification. The sample was exhibited during the Carnival of 1918 as one of our war minerals. However, Mr. Lednicky, who went to investigate the locality, informed us that the mineral might have been left accidentally by Moro or Chinese traders, as the formation in the place and its surroundings shows no possibility or probability of containing mercury deposits; nor could he find another float of the mineral.

COAL MINING IN THE PHILIPPINES

By LEOPOLDO A. FAUSTINO

TABLE 1.—*Philippine coal production from 1842 to 1918.*

Year.	Quantity.	Value.
	Metric tons.	*Pesos.*
1842-1906	30,000	450,000
1907	4,123	26,800
1908	10,035	77,166
1909	30,336	197,184
1910	28,655	176,255
1911	20,000	130,000
1912	2,720	20,200
1913		
1914		
1915		
1916		
1917	5,748	141,425
1918	15,663	385,400
Grand total	147,280	1,604,430

INTRODUCTION

After four years of more or less apparent inactivity coal mining in the Philippines began to show life and has again attracted the attention of both investors and the general public. It is to be hoped that local coal production will not meet another setback, and it is to be desired that it keep pace with the ever increasing demand for fuel by our manufactures and our commerce. It is to be regretted that the Philippine Islands produced no coal when the lowest grade of coal was commanding high prices in the Manila market. I hope to show that at no time during the last few years could coal have been said to be plentiful, and there are times when prices were almost prohibitive. It then becomes apparent that a ready market is awaiting coal, and since the question of market is the first consideration in coal mining the future holds great promise for those connected with the industry.

The year 1912 recorded a production of 2,720 tons of coal. The small production was due to several causes. During the year the mine of the East Batan Coal Company was flooded and the Camansi mine in Cebu was visited by a typhoon which wrecked the surface plant. Since October of that year until the beginning of 1917, there was no commercial production. In 1917 we first heard of coal being mined and offered for sale in Batan and Cebu, and early that year reports of production were received, which predicted that coal mining was again coming into its own. More than 5,000 tons were produced in 1917, and probably more had been produced in smaller quantities which had not been reported to the Bureau of Science. In 1918 the Batan and Cebu fields were still the main producers, and it is safe to assume that these two fields will continue to supply most of the coal produced in the Islands.

The majority of Philippine coals falls under the class of lignite, but we have also a good quantity of the bituminous grade. The bituminous coal deposits in the Philippines are on Polillo Island, and in the Zamboanga district in southern Mindanao. No work of any kind, so far as we know, has been done on the Polillo deposit for the last two or three years. The National Coal Company, organized in April, 1917, controls the deposit in the Sibuguey district; but up to the present there has been no commercial production. The Bureau of Science is not aware of the difficulties of mining and exploitation which the National Coal Company is experiencing in the Sibuguey field. It has the information, however, that during the last two years the mines have not produced any coal for sale. This may be partially explained by the fact that previous exploratory work by drilling was sadly neglected, and the question of transportation was not thoroughly studied. We have information that the building of a 15-kilometer railroad is contemplated from the mine to a point on the coast. After core drilling the entire area, enough coal might be shown to warrant the building of the railroad.

EXPLORATION AND DISCOVERIES

During the last few years there has been comparatively little prospecting and, in consequence, very few discoveries of new coal seams have been reported. The Uling Mines Limited did some development work in 1916, but outside of this there was a general lull in the development of coal properties. There are comparatively few Filipinos who have dedicated themselves to mining, and the few who have acquired some knowledge of mines and mining usually find good employment in the larger mining companies. Prospecting is thus left in the hands of Americans and foreigners, and the majority of these have usually enough prospects on hand and do not care to go out and look for more. The Filipinos are by nature agriculturists rather than miners. It is hoped, however, that among the younger generation many will turn their attention to the mineral industries, and the greater part of the Archipelago will then be thoroughly explored.

The Bureau of Science has an arrangement by which carefully prepared samples from prospects in new territories may be analyzed free of charge; provided, however, that accurate information be given with regard to the approximate location, the thickness of the seam, distance from transportation, etc. This arrangement, it is hoped, will open up new fields and encourage prospectors to go out and discover new coal areas. It is admitted by all who have followed the development of the mining industry in the Philippines that the country is yet very much unexplored, and thorough prospecting of the more promising regions may reveal deposits of coal greater in quantity than those of any of the known fields.

Reports have been coming to the Bureau of Science telling of new coal discoveries, and in some instances requests have been made for an examination of the deposits. The Division of Mines was not able to comply with all the requests on account of reduced personnel, but it is hoped that with the termination of the war all vacancies will be filled and more parties can be put in the field for the purpose of investigating and reporting upon these discoveries.

There is the Lanao field which might be investigated. The Governor of Lanao says there has been considerable prospecting in the foothills near Iligan. No samples have been received from the district, and as far as we have been informed nothing has yet materialized.

The Governor of Nueva Vizcaya reports the existence of coal seams in his province. Our knowledge of the economic geology of eastern Luzon, however, tells us that usually coals discovered in northern Tayabas, Nueva Ecija, and Bulacan are lignite and a few inches in thickness, and that, therefore, those deposits are commercially unimportant. However, there have been some surprises in Philippine mining, and Nueva Vizcaya may have a coal deposit which will stand careful investigation.

Catanduanes Island looms up again as a possible source of a large coal supply. This island has been investigated by local companies, and extensive development work should show the commercial value of the deposits. The quality of the coal is well known, it being of the same grade as the Batan and Rapu Rapu, and the deposit might be worked profitably.

The coal deposit near the barrio of Salamanca, Escalante, Occidental Negros, has been investigated by the owners. The coal is lignite and has been found suitable for firing in the boilers of some of the interisland steamers. The coal outcrops on a river bank and, as the river meanders through the property, the seam has been exposed at several places. More development work is necessary to prove the commercial value of the deposit.

Panay will probably contribute to the 1919 coal production. There has been considerable prospecting in the latter part of 1918 near Buruanga, Capiz, and favorable reports have been received regarding the progress of the development work. The coal encountered is intermediate between peat and lignite, but has been successfully used for firing in the boilers of some of the interisland steamers when mixed with firewood. It will also find use in producer-gas engines and will undoubtedly give good results. The following is an analysis of Panay coal sent to the Bureau of Science:[1]

	Per cent.
Moisture	20.58
Volatile combustible matter	40.42
Fixed carbon	29.26
Ash	9.74
Sulphur (separately determined)	2.13
Calories	4870

The coal deposit in Cagayan in northern Luzon has not been heard from. Some work has been done in the Mindoro deposit near Bulalacao, but results of the development work are not available. The Cataingan deposit on Masbate Island has not gone beyond the prospecting stage. Nothing more has been heard of the Sorsogon deposit near Sugud. There are several other small localities where coal has been encountered, but nothing definite is known about them and in some instances the seams did not measure more than a few centimeters.

In 1918 great activity in coal prospecting was displayed in Cebu Island in the vicinity of Toledo and Naga. The greatest number of applications for revocable permits to prospect and mine coal came from this district and, while none of the ap-

[1] Analyzed by A. S. Argüelles.

plicants alone will be able to do work on a very great scale, nevertheless the number shows that the people of Cebu are awake to the possibilities of our coal-mining industry. As a matter of fact, Cebu Island to-day has the greatest number of coal operators, and it produces more coal than all the other districts combined. Coal was discovered in Cebu first, and coal operations there have been taken as a barometer of Philippine coal mining.

The Director of the Bureau of Forestry has instructed all rangers to report any outcroppings of coal met with in their forest investigations. On account of the thick tropical vegetation and the dense flora of our mountains, and since the rangers are the few Filipinos whose work takes them to the thick fastnesses of our forests, it is believed that this will be one of the most effective means of bringing to light coal fields hitherto undiscovered.

Ranger F. Balderrama reported the discovery of coal in the vicinity of Mauban, Tayabas, near Ligam River and Mount Batoc-toro. Detailed examination of the locality has never been made, but samples were brought to the Bureau of Science for analysis. The sample from near Ligam River was found to be very high in ash and, if a representative sample, the deposit would be of little commercial importance. That from Mount Batoc-toro contained only a little more than 12 per cent of ash. The latter deposit might be investigated to determine its commercial value.

MINES AND MINING

At the close of 1918 twenty-three mines were producing coal in greater or less quantities. This number includes many of the "wagon" mines (so called in the United States), and also a good number of the "paquiao" or contract mines. The total number of men engaged in coal production was a little over one thousand. The miners, with few exceptions, are Filipinos; but the supervision is largely in the hands of Americans and Europeans who serve as foremen, scientific assistants, superintendents, and managers.

A modified form of the room-and-pillar system of mining is used by the more-developed mines. The Philippine Coal Mining Company, at Batan Island, Albay; the National Coal Company, at Danao and Compostela, Cebu; the Uling Coal Mines Limited, at Naga, Cebu; the Danao Coal Mining Syndicate, at Danao, Cebu—all use this modified form. The rooms do not take the size and shape of rooms commonly found in room-and-pillar mines in the United States. Most of the rooms are also entries. The operators of the "wagon" mines usually begin their work on the outcrop and follow the seams in whatever direction they go underground, whether they incline or pitch perpendicularly, until the men can no longer do any work, or until the coal can no longer be taken out profitably. Then the place is abandoned, and work is begun on another outcrop. This, it is hardly necessary to state, is a wasteful method of mining coal, and of course such operations are short lived. The "paquiao" or contract mines are worked by the same method; the men are paid so much for coal taken out, or so much per foot of tunnel or slope advanced.

The seams dip at all angles up to 90° and strike in all directions. The persistence and permanence of the seams cannot be predicted with accuracy, as faults are found to exist and seams tilt at angles and in directions almost inconceivable. The seams range from a few centimeters to 2 meters in thickness. In the absence of definite geologic correlation, the uppermost seam in any given mine is called No. 1 seam; the second, No. 2; and so on. No. 1 seam of one mine, therefore, may not be No. 1 of a neighboring mine. This numbering of seams has been arbitrarily made. When a more thorough geologic investigation of the coal districts is made and all the seams are correlated, new numbers will be given and these will be permanent.

With one exception, Philippine coal mines are non-gaseous. The exception is the Danao mine in Cebu, where mine gas has been encountered in one of the shafts. The roof and walls of rooms and entries are generally good. Some mines are not even timbered, although there are some that require very heavy timbering; when much timber is required, the cost of getting the timber is usually a heavy item in the expense account. The expense of timbering is especially high when the mine is a good distance from the timber supply. Water is generally present, and some mines might be called wet mines. Drainage is taken care of either by ditches on the sides of the tunnels or by ordinary hand pumps. Most mines have natural ventilation, but quite a few have, in addition, artificial ventilation. Where natural ventilation is used, the mine is usually provided with two shafts as air passageways or a shaft and a tunnel. One serves for the introduction of fresh air, while the other serves for the egress of the current after it has passed round the working places. Where mechanical ventilation is provided, it is usually by means of a fan driven by an engine. Candles and lamps using coconut oil are the commonest forms of lighting. Naked lights are in general use, except in the mine where mine gas has been encountered, and there safety lamps are being used.

There are few accidents and these mostly of a minor nature. This is a very commendable feature of Philippine coal mining and one that speaks well for the management of the big coal companies. The Bureau of Science cannot emphasize too strongly the extreme necessity of enforcing safety-first rules, and it hopes that the number of accidents reported will not increase with the increased production. The common laborer in a coal mine does not realize the danger about him to any great extent and, after having worked inside the mine for some time, he becomes so accustomed to existing conditions that he forgets to be careful, when usually some accident results. A great many mine accidents are caused by the carelessness of the workmen, and those in charge of them cannot be too watchful. So far there are no regularly appointed coal-mine inspectors. It is hoped that the managers of the different coal companies will consider the safety of their employees and conduct thorough inspection of the working places, to ensure the safety not only of their workmen but also of their mines. Medical attendance is provided for in the big mining camps, and some companies regularly employ doctors. The prevention of the spread of contagious diseases and the improvement of the general health of the community benefit the operating company.

PRODUCTION AND CONSUMPTION

There is no reason why any coal need be imported into the Philippines, if Philippine coal can be made available for use. The Philippine Islands does not need the best grade of coal from abroad as this is a tropical country and not a temperate one, and an agricultural rather than a manufacturing one. The expenditure of nearly 5,000,000 pesos in 1918 and more than 3,000,000 pesos in 1917 for imported coal is unnecessary, and our interests would be best served if we were to direct our attention to the utilization of our own coal resources. The ever-increasing industrial activity and the springing up of manufacturing centers all point to one thing; namely, that our coal consumption will increase from year to year, and that we will have to increase either our local production or our importation of coal from abroad.

Coking coal occurs in Cebu Province, but the seams have not yet been proved economically important, and the coal has not yet been available for coke manufacture. The Manila Gas Corporation manufactures coke locally, but from Japanese coal. The coke produced is used by foundries, blacksmiths, and candy manufacturers.

The production of coal in the Philippines was largest in 1909, when over 30,000 tons were produced, worth then 197,184 pesos. In 1918, with a production of half that for 1909, the value was nearly double. That is to say, the price of native coal has advanced 400 per cent during the last nine years. To date the Philippine Islands has produced 147,280 tons of coal, valued at 1,604,430 pesos. Serious work in mining began in 1890, and in twenty-eight years we produced about one-third of the coal imported during 1918.

TABLE 2.—*Importation of coal and coke into the Philippines from 1916 to 1918.*

	1918		1917		1916	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
COAL.	*Metric tons.*	*Pesos.*	*Metric tons.*	*Pesos.*	*Metric tons.*	*Pesos.*
United States	6	308	4	153		
China	94,344	845,119	47,741	292,457	49,698	248,709
Japanese China	39,737	200,278	46,645	275,502	49,900	254,851
British East Indies	18,905	222,172	10,591	109,259	5,894	37,545
Dutch East Indies	3,251	37,161				
French East Indies	6,502	55,972	2,817	21,863		
Japan	229,380	3,158,052	293,804	2,359,838	356,310	2,059,286
Australasia	10,331	116,445	1,905	17,398	1,585	7,597
British Africa	2,654	26,842				
Total	405,110	4,662,349	403,507	3,076,470	463,387	2,607,988
COKE.						
United States	126	15,451	9	798		
United Kingdom					20	525
China	933	39,219	676	18,687	427	5,563
Japanese China			157	4,340		
Japan	376	22,754	240	11,147	500	9,841
Australasia	705	23,286	53	2,074		
Total	2,140	100,710	1,135	37,046	947	15,929
Total coal and coke		4,763,059		3,113,516		2,623,917

POSSIBILITIES AND PROSPECTS

The possibilities of the coal-mining industry in the Philippines should be considered in a broad way. Quantity and quality should not be the only considerations, because the question of market is of prime importance. The physical and, more particularly, the chemical properties of a coal are the factors that largely determine the use for which it can be made available. We have a fair idea of the quantity and quality of our coal; it remains to show that the same coal can be made available for our use and, that proven, a ready market is assured. With Philippine coal the Bureau of Science has been able to produce electric power, by means of its 67-horsepower Otto suction producer-gas plant, at 3.3 centavos per net kilowatt hour. Ycasiano says:[2]

> One of the means that will undoubtedly solve the problem of efficient utilization of Philippine coals of all grades, besides their use in the producer-gas plants, will be the installation of machinery to make powdered coal for industrial use and for firing in furnaces of locomotive, marine, and stationary boilers.

It is hoped that the Bureau of Science will be able to secure an appropriation to buy and install such machinery and, if the use of such machinery be proven commercially profitable, no doubt the coal-mining industry will then go forward by leaps and bounds.

A great many of the interisland steamers have tried Philippine coals in their boilers and have found that our poorest lignite, if mixed with Japanese or Australian coal, or with firewood, gives satisfactory results. Batan coal finds ready sale in Albay and Sorsogon and is used in operating hemp presses, road rollers, stone crushers, and ice plants, and even the Manila Railroad Company uses some. The Sibuguey coal compares favorably with any of the imported coals, as shown by analyses made in the Bureau of Science, and would furnish the Japanese and Australian coals a strong competitor in the coal market.

Probably the greatest drawback in Philippine coal mining is the difficulty of transportation. The lack of good roads makes it difficult and sometimes impossible to transport the mined coal to where it can be offered for sale. Mines are sometimes located in almost inaccessible parts of mountains, and coal is carried down on the backs of carabaos or the shoulders of men. Carts drawn by cows furnish transportation from the foot of the mountains to the beach or landing or to the railroad. Extensive development of the coal fields will begin with the building of roads and railroads to them; as, unless the mined coal can be profitably marketed, mining operations would be just as they have been in the past.

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[2] Min. Resources P. I. for 1915 (1916) 32.

CONCLUSION

If the first six months of 1919 are taken as a criterion, the production for 1919 will be twice that for 1918. The National Coal Company expects to be the largest producer, and while it has much to do still, it is hoped this expectation may be realized. At present the Philippine Coal Mining Company heads the list of coal producers.

The Coal Leasing Act went into effect in 1917. The Rules and Regulations of the Secretary of Agriculture and Natural Resources were published in August, 1917. They provide for the rendering of reports to the Bureau of Science, and the operators have all complied with this requirement. The productions were reported in tons of 1,016 kilos, according to provisions of law; but, in as much as a common unit is necessary throughout the tables so that quantities might be compared with each other, the statistics of production in Table 1 are given in metric tons.

NONMETALLIC MINERALS

By Leopoldo A. Faustino

ASBESTOS

The manufacture of asbestos products is a new industry in the Philippines and deserves special mention. While asbestos deposits have been known since 1907, there was no commercial exploitation until 1918, when native asbestos became available for manufacturing purposes for the first time. Serious work in asbestos mining began in the latter part of 1918, when a German firm, The Philippine Cement Products Company, built a plant in Santa Ana, Manila, for the manufacture of asbestos products. To supply this plant with raw materials, the Ilocos Norte asbestos deposits have been worked. At the beginning of 1919 both the deposit and the plant became the property of the Ilocos Asbestos Products Company.

At the present time asbestos mining is confined to the Ilocos Norte asbestos area, although some production in Pangasinan near Salasa has been reported. The Ilocos Norte asbestos field has been fully described by Smith.[1] Considerable development work has been done on the property but more work is necessary to delimit the asbestos-bearing area commercially exploitable. There are indications, however, that the area is large and that it will, if properly worked, furnish asbestos in sufficient quantity to keep the plant working for a number of years.

Exploitation will be easy, and ordinary quarrying methods will probably be used. The question of transporting the crude asbestos from the quarry to a point near the seacoast, where it may be loaded on ships to be sent to Manila, is the serious problem. The Bay of Bangui is safe only when the north monsoons are absent, which is probably for less than three months of the year. There are few good harbors along the western coast. Among these Dirique probably offers the best facilities. Native carts drawn by oxen might be used for transporting overland the boxes of crude asbestos.

A sample of asbestos said to be from Pangasinan was submitted to the Bureau of Science for examination and was found

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[1] Philip. Journ. Sci. § A 2 (1907) 145.

to be brittle asbestos, a variety of amphibole. This variety, according to the United States Bureau of Mines, is valuable for pipe and boiler covering, and similar uses. The same authority contends that it would not bear transportation and therefore cannot be exported profitably. With regard to the same mineral the Japanese Museum says that a similar grade is used in Japan in paint manufacture.

Asbestos is reported to occur also in Zambales and in Antique. The Zambales deposit is near Subic, within the Army and Navy reservation. Samples submitted by prospectors are identified as amphibole and chrysotile. A detailed examination of the Antique deposit has not yet been made.

PETROLEUM

Philippine petroleum has attracted considerable attention, both here and abroad, and inquiries regarding the different known fields have been received at the Bureau of Science from time to time. The interest which manifested itself ever since the announcement was made that the Tayabas field was believed to be worthy of exploration by drilling has continued unabated. In 1918 the interest began to assume definite form, and several companies signified their intention of sinking oil wells. It is safe to assume that there will soon be several parties in the field, and it is hoped that with the sinking of wells the existence of petroleum in quantity sufficient for commercial exploitation will be proved.

The possibilities of the petroleum industry in the Philippines cannot be overestimated. If petroleum could be made available in sufficient quantity, and at a cost that would enable interisland steamers and the railroad to use it instead of the imported coal, half of our fuel problems would be solved. Then again, on account of its growing commercial importance, we would undoubtedly see a greater number of American and European steamers calling at Manila—ships that use crude oil for fuel and that would oil here if they could. Our own interisland trade, now increasing at a tremendous rate, will demand more ships and we will be compelled to utilize other kinds of fuel besides coal. The development of the more promising fields is of first importance, and enough capital should be interested to bring the petroleum to the surface and make it available for commercial use. The extent of the Philippine petroleum industry can be gathered from the following table, taken from the Report of the

Insular Collector of Customs, regarding the importation of petroleum and allied products:

TABLE 1.—*Imports of petroleum products into the Philippine Islands from 1916 to 1918.*

Petroleum product.	1918		1917		1916	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Liters.	*Pesos.*	*Liters.*	*Pesos.*	*Liters.*	*Pesos.*
Crude oil, including all natural oils without regard to specific gravity	6,122,001	138,407	3,766,391	55,759	3,488,102	36,213
Refined or manufactured oil, naphtha, including all lighter products of distillation	6,667,652	1,106,229	11,841,579	1,672,755	12,649,911	1,563,224
Illuminating oil	24,668,198	2,426,920	43,492,596	2,673,335	41,099,713	2,025,691
Lubricating and heavy paraffin oil	4,139,207	796,718	2,834,246	538,615	3,043,305	435,846
Residuum, including tar, and all others from which the light bodies have been distilled	768,414	72,487	965,497	53,355	963,345	45,915
Total	42,365,472	4,540,761	62,900,309	4,993,819	61,244,376	4,106,889

At the present time the Tayabas field is the seat of most of the investigation and exploration. This and the oil districts of Cebu and Leyte were investigated by the Bureau of Science, and complete reports were published in the Philippine Journal of Science.[2] The other oil locality attracting attention is Mindanao in the vicinity of Lake Lanao and in the Cotabato district. Oil has been known to exist in Mindanao Island since Spanish times, but no systematic exploration has so far been made. Reports have reached us of some preliminary exploratory work being done by a large oil concern, but nothing has yet been made public. A few American prospectors are also in the district. The Bureau of Science hopes to be able to make an investigation of the locality for itself in the near future.

Recently the Bureau of Science was in receipt of two samples of oil said to have been collected in Mindanao; the exact location could not be determined. The only information available regarding its place of origin is to the effect that it was from the northern Cotabato district. The samples were seepage samples and were collected over water. It is to be expected that they

[2] Philip. Journ. Sci. § A 8 (1913) 301; § A 10 (1915) 241 and 281.

would show no gasoline and that the kerosene content would vary. Table 2 shows the results of the analysis made:[3]

TABLE 2.—*Analysis of oil samples from Mindanao.*

	1	2
Specific gravity at 15.6°C	0.9301	0.918
Distillation:		
Light oils (below 150°C.)	none	none
Burning oils (150°-300°C.) per cent	48	85
Heavy oils (300°-400°C.) do	50	11
Residue do	2	4
Sediment	slight	slight
Water	trace	
Base	paraffin	
Main calories or gross heating value calories	10,951	
Available heating value do	9,869	
Sulphur per cent	1.49	

SULPHUR

Sulphur occurs in more or less pure form around solfataras and also in a very impure state mixed with volcanic ash in Occidental Negros, on Camiguin Island of the Babuyan Group north of Luzon, on Camiguin de Misamis north of Mindanao, in Leyte, and on Biliran Island, with less important deposits in Taal Volcano, on Pocdol Mountain in Sorsogon Province, and on Mount Apo in Mindanao.

On the instance of the United States War Trade Board requesting information regarding Philippine sulphur deposits, Mr. V. Elicaño, of the Bureau of Science, was sent to Silay, Occidental Negros, and to Camiguin de Misamis, to investigate and report on the sulphur deposits there, which are said to be extensive. An extract from his report follows:

There are three different sulphur deposits, namely; the Malisbog, claimed by Mr. Gerardo Alunan; the one at Mount Azufre, claimed by a company called Los Valientes in which Senator Guanco. Mr. Ortega, Mr. Jalandoni, and others are interested; and the other one on the other side of Mount Azufre, also claimed by Mr. Gerardo Alunan. The Malisbog is about 29 kilometers from Silay, while the other two are at about 36 kilometers from the town. All of them lie in areas southeast of Silay.

There is a good automobile road of 13 kilometers to Guimbalaon barrio; from this to Agho there is a cart road of 3 kilometers; from Agho to the deposits there are only trails, which in some places are dangerous to follow due to the steepness of the hills. The deposits are all solfataric in character. The sulphur is found around vents from which emanate gaseous

[3] Analyzed by the Bureau of Science.

and steam vapors, those near the craters or vents being pure. The deposit claimed by the Los Valientes does not exceed 1 hectare in area, though the area claimed is 64 hectares. The total available ore in this deposit will probably not exceed 300 tons. The other claims are still smaller than that of Los Valientes.

The deposit at Camiguin de Misamis was also investigated by Mr. Elicaño, who reports it to be commercially unimportant. The accessible deposit is very small, and the question of transportation is a serious problem. The deposit has been known since Spanish times, and the Division of Mines has on exhibit at its display room some samples from the locality. It is not probable that the deposit will be worked, unless the price of sulphur materially increases.

The deposit at Camiguin, Babuyan Islands, was investigated by local capitalists and found to be worthy of exploitation. The engineer who examined the deposit made an exhaustive report on the possibilities of the sulphur industry being established in that locality. So far as we know, however, nothing has materialized as yet. It is probable that lack of sufficient capital to finance the work properly prevented the installation of machinery. The quality of the ore is good, and according to the report runs about 88 per cent sulphur. The report further states that there are more than 4,100 tons in sight.

At present the production of sulphur is confined to Mount Silay, Occidental Negros. The sulphur finds a market in Iloilo, and some is exported to Australia. The present price of native sulphur in Iloilo is about 5 pesos per picul, or approximately 80 pesos per ton. This price is sufficiently high for the sulphur mines to be profitably worked, but the ruling of the War Department prohibiting the exportation of sulphur, it being a war mineral, somewhat paralyzed the industry as there was no very great local demand for it. There are still in the neighborhood of 50 tons in the bodegas at Silay, Occidental Negros, and unless copra drying by the use of sulphur becomes popular, which will create a demand for this mineral, the present high prices will soon drop and sulphur mining may be abandoned.

MISCELLANEOUS

Cement.—The failure of the Rizal Cement Company at this time is very inopportune. It is to be regretted that the only cement factory in the Philippine Islands should fail, much more so when the causes of its failure are brought into consideration. The plant shut down in March, 1919, the company went into the hands of a receiver, and its affairs are still in court awaiting solution. The Rizal cement plant has been fully described by Witt in the Mineral Resources for 1916. The materials available and the local conditions governing the cement manufacture have been given in our previous issues.

The amount of cement consumed locally is valued at more than 1,000,000 pesos a year. According to the import records of the Collector of Customs, as shown in Table 3, the value of cement imported into the Islands in 1918 amounted to 996,855 pesos. With the curtailing of production of local cement, the bulk of the cement used in building construction must necessarily be imported. The cement manufactured by the Rizal Cement Company is of good quality and compares favorably with any found in the Manila market. No question had arisen as to local market for the product. As a matter of fact 3,850 pesos' worth of cement was exported to China in 1918.

Several reasons are assigned for the failure of the company. There are some who claim that the labor element in Binañgonan was very hard to deal with and that they were given to strikes on the slightest provocation. It has been said, however, that if the laborers went on strike often it was because they were not treated properly and the management did not know how to handle them. There are others who claim that the price of coal was prohibitive and that the supply was limited. It has also been said that, while it was true that the price of coal went up, there was a corresponding increase in the price of cement. Then it was pointed out that the plant had been run whenever there were men to run the machinery and so the limited coal supply could not be given much credit as a cause for failure. Still others maintain that the failure of the company was due to the division of authority and responsibility between the technical director and the superintendent of the plant. When these two heads ceased to act in harmony the output of the plant suffered. The technical director claimed he did not have full control of the laborers, while the superintendent argued that the operation of the machinery was within his jurisdiction.

Table 3 shows cement consumption in the Philippines during the period from 1916 to 1918:

TABLE 3.—*Consumption of cement in the Philippine Islands during the calendar years 1916 to 1918.*

Source.	1918		1917		1916	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	bbl.	*Pesos.*	*bbl.*	*Pesos.*	*bbl.*	*Pesos.*
Rizal Cement Co	28,192	282,625	108,808	702,900	112,513	540,062
Imported	205,329	996,855	155,945	596,513	217,637	586,200
Total	233,521	1,279,480	264,753	1,299,413	330,150	1,126,262

The plant is still standing at Binañgonan. It is possible that operations may be resumed. In view of the increased activity in building construction, it could hardly be denied that a local cement factory is badly needed. The last production recorded was that for January and February, 1919, during which period 10,396 barrels were produced. During March, except for the manufacture of barrels, the plant was idle. It eventually shut down on March 15, 1919.

Fire-clay brick.—Experiments conducted at the Bureau of Science have shown the feasibility of using Los Baños clay for making fire brick. The brick has been used in our furnaces and has so far given entire satisfaction. Some of the trays used in our assay laboratory were made from Los Baños clay, and they have been successfully used in our gold-refining process. Attention should also be called to the fact that the brick was used in the construction of the Bureau of Science boiler. With the ever-increasing freight rates and the heavy demand for fire brick in the construction of boilers and furnaces, the Los Baños clay as a fire-brick material should appeal to brick manufacturers.

Lime.—The sugar industry is consuming some of the locally produced lime, and with the prevailing high price of sugar and the establishment of more sugar centrals the lime industry has bright prospects. We have excellent materials suitable for producing lime of the quality needed in sugar manufacture, and it is possible that at least the greater part of the lime used by sugar centrals may be produced locally.

Sand and gravel.—Sand and gravel used for construction and road work are obtained locally, and the prices paid for them are usually the haulage charges. Of course it goes without saying that the greater the distance between the source of the material and the place where the work is being done, the higher will be these charges. River beds furnish a good quantity of the sand and gravel used, but beaches and shore lines also furnish considerable. On account of the prevailing high prices, it has been reported to the Bureau of Science that as high as 4 pesos has been paid for a cubic meter of gravel and 3 pesos for sand.

Stone.—Crushed stone used in road building is also obtained locally, and as in the case of sand and gravel its price is usually that of transportation from the source to the site of work. Volcanic rocks, corals, limestones, the so-called "adobe" rocks, and andesites furnish the bulk of the stone used in road work. A kind of water-laid tuff is used in native construction and in building high walls around houses, but the quarrying of this stone is practically a household industry and it is not possible to keep accurate data on the number of blocks used each year.

Salt.—Reports from the salt-producing provinces in 1918 indicate large production throughout the different districts. It was even reported that in Cavite Province some of the camarins were filled to the ceiling and that sacks had to be piled outside. It will be remembered that the dry season of 1918 was one of prolonged drought, which made possible a large production of salt. The bulk of the salt is produced by solar evaporation of sea water.

Mineral and artesian water.—The Los Baños Improvement Company is manufacturing the popular "Isuan," bottled at the Los Baños mineral spring. The Los Baños and the Sibul springs are the two most popular bathing resorts, and during the year thousands of visitors from all over the Islands flock there for treatment, recuperation, and pleasure. The hotel adjoining the bathing establishment at Los Baños can accomodate about 30 guests.

The sinking of artesian wells has continued, and indications are that more will be sunk in the future. Artesian wells have done much in improving the general health of the community. According to the artesian well division of the Bureau of Public Works there were completed 179 drilled wells in 1918 as compared with 117 in 1917. Of the number of drilled wells in 1918, 14 were unsuccessful, while in 1917 the number was 7. In 1918 the flowing wells were 71 and the pumping wells 94, while in 1917 the flowing wells were 36 and the pumping wells 72.

In Manila several artesian water companies have been formed, and these are supplying Manila residents with drinking water at nominal cost. Among these may be mentioned the P. B. Artesian Water Company, The A. S. Watson Company, Corporation Marilao, Bucal Artesian Water Company, and others. The value of the combined output of the several companies was about 50,000 pesos in 1918.

THE PHILIPPINE ASBESTOS INDUSTRY

By W. H. Overbeck [1]

The manufacture of asbestos goods is at present a very important industry, both in Europe and on the North American Continent. Up to 1878 goods manufactured of asbestos were very few; the only kind of asbestos of commercial use known at that time was the Italian variety. The manufacture of articles of merchandise, composed wholly or in part of asbestos fibers, is steadily increasing in both volume and number of products, and this material is being utilized in many of the luxurious appointments of modern life. Since it is recognized as an important texture of safety, there can be no doubt that new uses will continuously be made of the mineral, and that there will be a constantly growing demand for it.

The application of asbestos seems to vary greatly in different countries. While in the United States large quantities of short fibers are used in manufactures of all descriptions, the European market calls for long fibers principally.

In 1917 I conducted some experiments with Philippine asbestos found in Ilocos Norte Province, P. I. In the beginning only amphibole asbestos of very soft and short fiber was obtainable. In a small plant built at Manila the following asbestos articles were manufactured: Asbestos roofing, asbestos sideboards, asbestos shingles, asbestos steam-pipe coverings, high-grade asbestos cement, asbestos stucco, asbestos ceiling boards, asbestos mastic, and asbestos paints.

ASBESTOS BUILDING MATERIAL

The trend of modern architectural and municipal thought in the erection of buildings is generally directed toward the utilization of fireproofing or fire-retarding materials. In this type of construction asbestos plays an important part. Asbestos is a natural heat insulator and its silky and flexible fibers are capable of manipulation into any form.

One of the largest future uses for asbestos fibers, which promises to become the largest future use for the clean short fiber,

[1] Civil Engineer, Technical Director of the Ilocos Asbestos Products Co.

will be in the manufacture of asbestos roofing slates. The present demand for asbestos fiber in the manufacture of slates amounts to about 50,000 tons a year in the United States, and it is still increasing daily.

Asbestos building material is practically indestructible by atmospheric influences, so the maintenance expense for roofs covered with this material is minimized.

For a period of three months the asbestos-cement slate absorbs and assimilates moisture in exactly the same ratio as the best natural slate. After that the absorption ceases altogether, and the material becomes impervious, indestructible, and very hard. The stringy asbestos fibers, which by the characteristic peculiarity of a patented process are embedded crosswise in the cement paste, have exactly the same effect as steel in concrete construction. They impart to the asbestos slate extremely high physical strength, affording resistance either to blow or to shock, as well as great elasticity, which qualities are as important as durability and length of service.

The insulating capability of asbestos, when subjected to either heat or cold, imparts an increased importance to asbestos-cement slate, and makes its use suitable not only in the Tropics, where it is commonly used as a corrugated iron, but also in the continental climate, where it is economically used in workshops, in dwelling houses, and particularly in garrets, which with other roof coverings would have to remain unoccupied.

The fireproofing quality of asbestos renders asbestos-cement slate a thoroughly fireproof material which, owing to its strictly scientific manufacture, does not crack, rent, or scale in case of fires.

ASBESTOS AS AN INSULATING MATERIAL

Asbestos is used in various ways for the purpose of preventing the radiation of heat from pipes, boilers, tanks, etc. As an insulating material it is claimed to be superior to most of the other non-conducting materials, both because of its capability of resisting heat, and because, being fibrous, it adheres better to smooth surfaces than do powdery substances. Numerous varieties of pipe and boiler coverings are on the market, and the large number of companies that make this class of product a specialty is evidence of the commercial importance this article has attained in the world.

The Ilocos Asbestos Products Company manufactures an asbestos cement containing 90 per cent asbestos fiber, which forms a light, porous covering that partakes of the nature of felt and cement, and is applied while hot to boiler or pipe surface.

Another mode of using asbestos for covering pipes is to form it in sectional pieces, which are placed on the pipes and connected by means of iron bands or canvas. This mode of applying asbestos has the unique advantage that not only can the covering be easily put on and taken off the pipe, but the same covering may be used for a considerable length of time. Special sectional pieces of such covering are made to fit elbows, tees, crosses, and other fittings.

ASBESTOS STUCCO

Asbestos stucco consists of asbestos and serpentine, and is consequently incombustible and fireproof. Its value, therefore, as a protection against fire when used for plastering walls and ceilings, is undeniable.

Asbestos stucco is now used in fireproof buildings in many American and European cities and other parts of the world, and it forms one of the principal fireproofing materials. It is generally made in two qualities, the "rough" asbestos stucco and the "finish" asbestos stucco. The former may be applied to the walls of a new building, upon brick, metal lath, plain boards, or expanded metal, and when dry will form a coating of the nature of asbestos felt board, which is used so much in the United States. This is then covered again with the "finish" which is carefully prepared with pure asbestos fibers of remarkable fineness.

ASBESTOS MASTIC

This product is a cementlike composition that is spread in one solid, unbroken layer over an entire roof, without a single lap, seam, joint or nail in the whole roof. It may be used for protecting new roofs over felt, concrete, wood sheathing, etc., or for resurfacing old felt, wood sheathing, or like materials.

No matter how old or worn a roof may be, it can be made absolutely waterproof with a coat of this preparation. It is not necessary to tear up the old material, as the plastic roofing can be spread directly over any warped or torn portions and will permanently stop the leaks. Aside from this application it might also be used as a caulking for ship bottoms; for stopping leaks in skylights; for repairing rain spouts, gutters, and valleys; for sealing up metal flashings; and for repairing leaks in copings, sidewalks, driveways, cisterns, tanks, etc.

The product is a combination of semidrying, carbonaceous materials which are thoroughly interlaced with long-staple asbestos fibers, and tempered by chemical fusion with heavy, water-proofing oil that adds materially to the life of the cement and so tempers the product that it will neither sag nor run at even the extreme of 200° F.

ASBESTOS PAINT

The manufacture of fireproof paint has, in recent years, assumed considerable importance. Nearly all manufacturers of asbestos goods make also asbestos paint in various colors.

These paints are suitable for rough woodwork, such as joints, rafters, beams, stairs, warehouses, and wooden structures of all kinds.

Numerous public experiments have been conducted from time to time in the United States proving the remarkable fire-resisting qualities of asbestos paint.

All asbestos products above mentioned have been manufactured for the last two years by the Ilocos Asbestos Products Company in Manila.

A most modern asbestos plant will soon be erected in Manila, and undoubtedly a very important industry will be added to the Philippine Islands.

PHILIPPINE MATERIALS SUITED TO THE MANUFACTURE OF GLASS

By T. DAR JUAN and V. ELICAÑO

The imports of glass bottles and other ordinary glassware into the Philippine Islands have exhibited an almost constant increase since 1914, sufficient to justify the establishment locally of a modern glass factory. Table 1 gives the value, at the ports of origin, of Philippine imports for the last four years:

TABLE 1.—*Philippine imports of ordinary glassware in 1915, 1916, 1917, and 1918.*

	1915	1916	1917	1918
	Pesos.[a]	*Pesos.*[a]	*Pesos.*[a]	*Pesos.*[a]
New empty bottles	129,197	158,419	193,093	440,090
Drinking glasses (Japan)	52,859	60,268	142,076	95,057
Lamp chimneys (Japan)	17,023	20,337	16,445	37,210
Total	199,079	239,024	351,614	572,357

[a] One peso Philippine currency equals 50 cents United States currency.

Technically speaking, there are two general classes of glass recognized, lime glass and lead glass. Lime glass is the commonest material for cheaper articles such as ordinary bottles, demijohns, jars, drinking glasses, lamp chimneys, etc., while lead glass is a more expensive product, and is used chiefly for cut glassware and for optical purposes. The principal raw materials used in the manufacture of lime glass are lime, silica, and alkali.

Lime silica.—Coralline and crystalline limestone of good quality, suitable for the manufacture of lime and glass, occur throughout the Philippine Islands, but the deposits most easily available to Manila are those of Montalban, Binangonan, and Tayabas. It is estimated that limestone may be obtained from any one of these places for from 5 to 8 pesos per metric ton, placed in Manila. The Bureau of Science in its experimental kiln has manufactured from Philippine limestone more than 100 tons of excellent lime, suitable for use in sugar centrals and in other industries, and there is no reason why first-quality lime cannot be produced locally in any quantity.

The principal source of silica is white sand or quartz. Extensive beaches of quartzose sand and massive quartz in lenticular veins occur in Mindoro in commercial quantities. Sand deposits of good quality are also found at Paracale, Camarines, and at Baguio, Mountain Province.

Typical analyses of these raw materials are given in Table 2:

TABLE 2.—*Composition of Philippine raw materials used in glass making.*

[Numbers give percentages.]

	Mindoro quartz.	Mindoro sand.	Lime-stone.	Hydrated lime, Bureau of Science.	Pasay beach sand.	Tarlac sand.
Loss on ignition	0.34	0.80	45.61	25.26	5.40	0.82
Silica	97.49	86.60	0.14	0.47	56.00	57.54
Ferric oxide		0.48			6.24	7.89
Alumina	1.58	8.12	0.14	0.39	19.16	20.47
Lime	trace	1.20	54.10	72.93	6.18	7.31
Magnesia	trace	0.22	trace	trace	4.34	3.27
Manganese oxide	trace		trace		trace	
Sodium and potassium oxides	0.50				2.66	
Undetermined		2.58				2.70

Alkali.—This material is derived from sodium carbonate or sulphate, which should be as nearly free from iron as is possible. Sodium carbonate or soda ash fuses more readily with sand than does sulphate; but, since the latter is a cheaper product, it is more generally used in glass making, especially in the production of the cheaper articles. When sodium sulphate is used, some form of carbon should be mixed with it to assist reduction. Sodium carbonate and sodium sulphate, which are intermediate products in the preparation of caustic soda, depending upon the process used, may be imported from the United States or prepared locally from common salt. During 1917 the Philippine Islands imported 1,423,532 kilograms of caustic soda valued at the port of origin at 326,813 pesos. The establishment in the Philippines of a caustic soda factory, in connection with a glass factory or a paper-pulp plant, will save to the Islands the value of their imports of this commodity and will encourage the exploitation in the Philippines of such industries as the manufacture of paper-pulp, glass, soap, etc., in all of which caustic soda or one or more of its intermediate products is used as raw material. In a soda factory the largest item is fuel, and the next, common salt. It is believed that, by establishing the factory in a place where there is a large supply of firewood, and where at the same time climatic conditions are favorable for the solar evaporation of sea water, sodium carbonate can be produced locally at approximately 102 pesos per metric ton.

In addition to the materials already described, broken glass, or "cullet," is invariably used in glass factories. The object of mixing cullet with the batch is to utilize the fragments of glass left over during the process of manufacture and to serve as a flux and to lower the temperature of reaction of the materials employed. Mixing the batch with cullet also considerably reduces the cost of production. However, in the experiments made by the Bureau of Science no cullet was used, because the main object of the experiments was to determine the suitability of Philippine materials for glass making.

Proportion of constituents.—The proportions in which the different ingredients of glass are mixed vary considerably, according to the quality and composition of the raw materials available, the quantity of broken glass mixed with the batch, the temperature available, and the quality and color which it is desired to give to the finished product. Table 3 shows the composition of the mixtures and the color of the glass obtained.

One of the most important operations in glass making is the mixing of the different materials to be melted in the furnace. In the Bureau of Science this operation was effected by passing the powdered materials several times through a sieve until the different particles were thoroughly incorporated.

The mixture thus prepared is converted into glass by fusion in a pot furnace. The process of melting consists in heating the pot to a temperature high enough to melt the charge; then the mixture of the raw materials is gradually introduced in small quantities, until the crucible is filled with molten glass. During the first stage of melting, the glass is full of bubbles, due to the air inclosed between the particles of the raw materials and the carbon dioxide formed during the reaction. However, by raising the temperature sufficiently high to keep the molten glass in a fluid condition the gas bubbles can be completely eliminated. When the test pieces of the molten glass are free from bubbles, the temperature is lowered sufficiently for the glass to become viscous. In this state a small quantity of glass can be coiled from the heated end of a glass tube or iron pipe and blown into a small hollow bulb. This operation is repeated until the required quantity of glass has been obtained. In order to give the glass bulb a smooth appearance it is rolled on a polished slab of iron, heated again, and then blown into a mold to give it the desired shape.

A number of glass bottles and jars have been made in the Bureau of Science, and the bottles were tested in local soda-water factories and breweries in order to detemine whether or

TABLE 3.—*Showing composition of mixtures and glass obtained.*

RAW MIXTURE IN PARTS BY WEIGHT.

Constituent.	Batch No. 1.	Batch No. 2.	Batch No. 3.	Batch No. 4.	Batch No. 5.	Batch No. 6.	Batch No. 7.	Batch No. 8.	Batch No. 9.	Batch No. 10.
Lubang quartz	100.0	100.0	100.0	100.0						80.0
Lubang sand					100.0	100.0	100.0	80.0	50.0	
Pasay beach sand								23.0	50.0	
Tarlac sand										81.0
Sodium carbonate	32.5	32.5	35.0	54.0	40.0	40.0	40.0	37.0	35.0	38.0
Limestone	38.8	38.8	25.0	23.0						
Hydrated lime					13.0	13.0	13.0	10.0	10.0	21.0
Arsenious oxide (As_2O_3)		0.2				0.3				
Manganese oxide (MnO_2)							0.25			

PERCENTAGE OF GLASS MATERIALS IN THE MIXTURE.[a]

Constituent.	Batch No. 1.	Batch No. 2.	Batch No. 3.	Batch No. 4.	Batch No. 5.	Batch No. 6.	Batch No. 7.	Batch No. 8.	Batch No. 9.	Batch No. 10.
Silica (SiO_2)	71.51		75.00	70.52	67.60			65.63	58.87	64.31
Iron and aluminium oxides (R_2O_3)	1.15		1.18	1.16	6.75			10.07	14.05	12.51
Lime (CaO)	15.39		10.40	9.00	8.34			7.67	9.05	10.96
Magnesia (MgO)					0.17			0.93	1.88	1.37
Alkalies (K_2O+Na_2O)	11.95		13.42	19.32	17.14			16.30	16.15	10.85
Arsenic (As)										
Manganese (Mn)					trace			trace	trace	

PERCENTAGE COMPOSITION OF GLASS OBTAINED.

Silica (SiO_2)	70.14	70.20	74.55	70.80	[b] 66.30	67.00		[b] 64.60	[b] 60.00	64.08
Iron and aluminium oxides (R_2O_3)	1.65	1.63	2.20	1.21	7.40	7.45		10.70	13.68	13.72
Lime (CaO)	16.90	16.84	10.50	9.55	8.50	8.40		7.48	9.84	10.72
Magnesia (MgO)					0.38	0.32		1.16	1.36	1.56
Alkalies (K_2O+Na_2O)	11.21	11.18	12.77	18.40	[c] 16.92	16.80		15.94	[c] 15.1	9.96
Arsenic (As)		nil				nil				
Manganese (Mn)					trace	trace		trace	trace	trace

[a] Calculated from the analyses of the ingredients of the raw mixture. [b] Analyzed by F. Peña, chemist, Bureau of Science. [c] By difference.

1. Yellowish tinge. 2. Lighter than No. 1. 3. Yellowish tinge. 4. Yellowish tinge. 5. Greenish. 6. Lighter than No. 5. 7. Lighter than No. 5. 8. Green. 9. Dark green. 10. Dark green.

not they would stand the pressure and the sudden changes of temperature to which glass bottles are subjected in a factory under ordinary working conditions. The results of these tests have been very satisfactory.

The Bureau of Science glass products have been exhibited to a glass expert who reports the results excellent. There is nothing to be desired except to improve the workmanship, which will settle itself when the equipment of a modern glass factory is available.

All this work proves beyond doubt that raw materials found in the Philippine Islands are suitable for glass making.

MINING LEGISLATION IN THE PHILIPPINES

By Victoriano Elicaño

In the review of mining activities in the Philippines, mention was made of the creation and organization by the Government of several national companies to engage in mining and manufacturing enterprises and to promote the economic development of the country in general. It is clear that the purpose of the Government in these organizations is twofold: First, to develop and place on a paying basis a sufficient number of mining enterprises to demonstrate to capital the feasibility of making such enterprises profitable; and, second, to create, during this period of high cost of materials, a local production of such prime necessities to our industries as coal, cement, and iron, and to establish a trade that will continue when normal conditions return. In this respect I believe the Government has taken the proper steps, although to accomplish its ultimate purpose, that of spreading interest in the development of the mineral resources of the Philippines, further and more necessary measures should be taken, and these are the revision of our present mining laws and the establishment of a school of mines.

Valuable drafts of mining laws concerning systems of alienation of mining lands, of reforms in the corporation laws related to mining, of changes in mining taxation, of rules regarding mine operations, and other valuable suggestions have been offered and submitted in the past few years by members of the Division of Mines and by private persons interested in the progress of Philippine mining. The time is, I believe, ripe for the Government to consider these suggestions on their merits, and to start building the Philippine mining industry upon a firm foundation. Radical changes are generally opposed, but opposition will not be incurred when, if drastic measures are taken, they have for their object advancement and improvement. Up to certain points it is possible to compromise the interests of the Government and of capital for the special benefit of the country, and now is the time to make these necessary points clear, if it is desired not to check the growing interest in mining in the Philippines.

Revision is necessary in the method of disposing of our mineral lands. The relative merits of the system of alienation of mining properties by leasehold, as compared with freehold, is a question on which there is a diversity of opinion, even among those best qualified to judge. The mining laws of the United States are based upon the freehold system. While the mining industry of the United States has made great progress under the existing laws, yet there is a general impression among mining men that a leasehold system would be preferable; and the fact that vast mineral resources have already passed into private control in the United States is causing considerable agitation for the substitution of the leasehold system for the freehold system. The former could be introduced here in the Philippines, and the law would effect a marked improvement over the present practice, which is only retarding the development of our mineral resources. The present law requires that 200 pesos worth of development work be performed each year on located, unpatented claims in order to insure the development of the land. This does not always accomplish the purpose sought by either the Government or the claim holder. Even this small amount of assessment work is avoided by the speculating claim holder by means of a system of relocation each year under the names of different persons who in reality are only figureheads; furthermore, as soon as the claim is patented, all control passes from the Government and the claim may never be developed further. The remarkable success which has attended the leasehold system in Australia, and the fact that a considerable proportion of the minerals recovered, even in the United States where the freehold system applies, are from leased properties held by private interests, are strong arguments in favor of the leasehold system, and there is no doubt that its introduction in the Philippines would prove successful.

Due consideration should be given to the proper size of mining claims or leasehold to be granted. This should vary with the kind of mineral and its mode of occurrence. In this country where the nature and the character of the mineral deposits are still little known, the Government cannot be too liberal in granting rather extensive areas, although persons or corporations should not be permitted to hold large areas of mineral lands unless they make some effort to develop them.

Royalties, rentals, and taxes are very important items that require careful attention. The question as to the best method of mine taxation is at present far from settled and should be carefully considered by those conversant with the mining industry. This industry is still in its infancy in the Philippines. Though some progress has been made and dividends are being paid by some of the mines, these facts do not necessarily indicate an ability on the part of the industry to meet in the future any additional expense in the shape of heavy taxation.

Drafts of proposed laws governing mining corporations were submitted some time ago. A great portion of the proposed legislation covers ground outside the province of the Division of Mines, but such measures as are designed to prevent the exploitation of the public by unscrupulous corporations are highly commendable and would undoubtedly promote the industry in the Philippines. The issuance of misleading prospectuses would only turn the investing public very bitterly against the industry. The nature of the business is risky enough to start with, and there is no need of making it more so. I believe the Government cannot take too drastic a measure along this line.

The slow progress of mining in the Philippines is partly due to our present faulty mining laws, and the Government should take proper steps to revise them if we do not wish to turn away American, foreign, and even Philippine capital that has recently shown interest in the development of our mineral industry.

Before closing, however, I wish to suggest the enactment of a measure which does not concern mining operations, but relates to their future rapid progress. This is the establishment of a mining school. The lack of technical men felt recently, not only by the Government but also by private operating companies, is a strong reason for this suggestion. The Filipinization policy started by the Government in its bureaucratic departments should be extended to the recently created national mining companies, and it should be the duty of the Government to prepare such men. Private companies will need Filipinos in their technical departments, as the importation of men of such knowledge becomes more difficult every year. A mining education taken in a Philippine School of Mines will be valuable because the graduates will become acquainted with actual conditions and problems generally encountered in local mining operations. An opportunity can be given to bright graduates to acquire broader knowledge in their profession by sending them abroad. This practice is followed by Japan, China, and many South American countries. I have no doubt that the creation of such a school will be of great benefit to the country, and will fill the great gap existing in the development of our mining industry.

DIRECTORY OF MINE OWNERS, MINE LESSEES, DREDGING COMPANIES, AND COAL OPERATORS IN THE PHILIPPINE ISLANDS

By LEOPOLDO A. FAUSTINO

Several requests for a complete list of mining and dredging companies operating in the Philippine Islands have been received at the Bureau of Science and to comply with these, the majority of which were from the United States, the appended list has been prepared. This list is made up of mine owners, mine lessees, dredging companies, and coal operators who have been mining or doing some development work during 1918. The companies and individuals are listed according to product and in alphabetical order. This arrangement, it is hoped, will best serve those who wish information concerning any company now operating mines or dredges in the Philippine Islands.

It will be noted that there are as many coal operators as there are gold producers, but this should not be taken to mean that as many people are engaged in coal mining as in working for gold. The majority of the coal operators are holders of revocable permits. Their area of operations is limited to 4 hectares each, and not very many of them would last more than a year or two.

There are many more mines that might be included in the list, but they are omitted for the reason that we have no definite information regarding them. Then there are some prospectors who do not believe in conservative advertising, and we regret to say that some have not answered our repeated requests for information regarding their development work. The Bureau of Science hopes to visit all prospects, but in the absence of favorable reports it has been deemed advisable to direct the investigations to the more promising fields. The coöperation of prospectors and mining men in general is absolutely essential to the carrying out of our work in disseminating information to the mining public, with which we hope best to assist the development of the mining industry.

We request that anyone connected with the mining industry whose name does not appear below will communicate with the Bureau of Science, so that the next issue of the directory will be more complete.

Directory of mine owners, mine lessees, dredging companies, and coal operators in the Philippine Islands.

GOLD MINES.

Name.	Post-office address.	Location of mine.
Acupan Mining and Milling Co	c/o Wm. M. Haube, 827 R. Hidalgo, Manila	Baguio, Mountain Province.
Antamok Valley Mining Association	c/o Wolfson & Wolfson, 65 Plaza Cervantes, Manila	Do.
Balete Mining Syndicate	Aroroy, Masbate	Balete, Aroroy, Masbate.
Benguet Consolidated Mining Co	Kneedler Building, Manila	Baguio, Mountain Province.
Cansuran Mining Co	Uy Chaco Building, Manila	Cansuran, Surigao, Surigao.
Colorado Mining Co	do	Aroroy, Masbate.
Gillies, John S	Suyoc, Mancayan, Mountain Province	Suyoc, Mancayan, Mountain Province.
Headwaters Mining Co	Baguio, Mountain Province	Baguio, Mountain Province.
Hora, A. W	Suyoc, Mancayan, Mountain Province	Suyoc, Mancayan, Mountain Province.
Malaguit Dredging Co	Uy Chaco Building, Manila	Malaguit River, Ambos Camarines.
Mambulao Placer Co	107 Escolta, Manila	Bulalacao Bay, Mambulao, Ambos Camarines.
Maximelo Dredging Co	Paracale, Ambos Camarines	Maximelo Creek, Paracale, Ambos Camarines.
Mentzer, George	Binalonan, Pangasinan	Lubang, Mountain Province.
Moisan and Müller	Maliit, Mambulao, Ambos Camarines	Maliit, Mambulao, Ambos Camarines.
Napuangan	Napuangan, Aroroy, Masbate	Napuangan, Aroroy, Masbate.
Paracale Bucket Dredges, Ltd	Paracale, Ambos Camarines	Paracale River, Ambos Camarines.
Paracale Venture Corporation	c/o B. A. Green, 34 Escolta, Manila	Paracale, Ambos Camarines.
Philippine Dredges, Ltd	Paracale, Ambos Camarines	Paracale River, Ambos Camarines.
Philippine Exploration Co	Uy Chaco Building, Manila	Mambulao, Ambos Camarines.
Schwab, Paul	Aroroy, Masbate	Aroroy, Masbate.
Surigao Gold Mining Co	c/o Cansuran Mining Co., Uy Chaco Building, Manila	Cansuran, Surigao, Surigao.
Syndicate Mining Co	101 Lara, Manila	Aroroy, Masbate.
Whitmarsh, H. P. & Co	Baguio, Mountain Province	Baguio, Mountain Province.

COAL MINES.

Abella, Apolinar	Cebu, Cebu	Lotloton, Toledo, Cebu.
Adlawan, Monico	Talisay, Cebu	Poog, Toledo, Cebu.
Alferes, Placido	Toledo, Cebu	Cantabaco, Toledo, Cebu.
Cabigas, Eugenio	Camp 8, Toledo, Cebu	Pugahan, Toledo, Cebu.
Engbino, Mamerto A	Minglanilla, Cebu	Tipulo, Toledo, Cebu.
Enriquez, Eugenio	1 Manila Street, Cebu, Cebu	Guinkiyutan, Toledo, Cebu.
Enriquez, Isidoro N	P. O. Box 5, Cebu, Cebu	Pinamanagan, Toledo, Cebu.
Enriquez, Manuel	217 C. Padilla Street, Cebu, Cebu	Do.
Evangelista, Martiniano D	Toledo, Cebu	Guinkiyutan, Toledo, Cebu.
Gracia, Pedro Pañares de	Naga, Cebu	Alpaco, Naga, Cebu.
Iriarte, Prudencio	100 Juan Luna, Cebu, Cebu	Cantabaco, Toledo, Cebu.
Lebumfacil, Lorenzo	Toledo, Cebu	Do.
Montalaba, Jose	do	Biga, Toledo, Cebu.
National Coal Co	174 Real Street, W. C., Manila	
(1) Sibuguey District	do	Sibuguey, Zamboanga.
(2) Cebu District	do	Licos, Danao, Cebu.
Nichols, J. Clayton	Danao, Cebu	Camansi, Danao, Cebu.
Peñalosa, Rafael E	Toledo, Cebu	Magdugo, Toledo, Cebu.
Philippine Coal Mining Co	P. O. Box 752, Manila	Batan, Rapurapu, Albay.
Rivera, Teofilo	Naga, Cebu	Cantabaco, Toledo, Cebu.
Sarabia, Federico B	42 Escolta, Manila	Santander, Buruanga, Capiz.
Toledo Coal Co	Box 494, Manila	Taop, Toledo, Cebu.
Uling Coal Mines, Ltd	Cebu, Cebu	Uling, Naga, Cebu.
Unabia, Alejandro L	Minglanilla, Cebu	Biga, Toledo, Cebu.

Directory of mine owners, mine lessees, dredging companies, and coal operators in the Philippine Islands—Continued.

IRON MINES.

Name.	Post-office address.	Location of mine.
Concha, Francisco de la	Sibul Springs, Bulacan	San Miguel, Bulacan.
Concha, Joaquin de la	Cabanatuan, Nueva Ecija	Do.
Cruz, Anacleto	Angat, Bulacan	Angat, Bulacan.
Fernando, Juana A	do	Do.
Fernando, Maria A	do	Do.
Fernando, Matias A	do	Do.
Fernando, Valentin A	do	Do.
Manila Iron and Steel Co	Manila	Mariveles, Bataan.
Philippine Mining and Industrial Co	Kneedler Building, Manila	Calambayanga Island, Mambulao, Ambos Camarines.
Sarmiento, Marto	Angat, Bulacan	Angat, Bulacan.
Vamenta Chaves Mining Co	Cagayan, Misamis	Bukidnon, Mindanao.
Wilson, Chas. N	Angat, Bulacan	Angat, Bulacan.

SULPHUR MINES.

Name.	Post-office address.	Location of mine.
Alunan, Gerardo	Silay, Occidental Negros	Silay, Occidental Negros.
Los Valientes	do	Do.
North Camiguin Sulphur Co	Manila, P. I	Camiguin Island, Luzon.

ASBESTOS QUARRY.

Name.	Post-office address.	Location of mine.
Ilocos Asbestos Products Co	Manila	Baruyen, Bangui, Ilocos Norte.

	ASPHALT MINE.	
Leyte Asphalt and Mineral Oil Co.	Villaba, Leyte	Villaba, Leyte.
	COPPER MINE.	
Mancayan Copper Mines	Mancayan, Mountain Province	Mancayan, Mountain Province.
	LEAD, ZINC, AND COPPER MINE.	
Marinduque Mining Co.	c/o E. E. Elser, Kneedler Building, Manila	Marinduque Island.
	MANGANESE MINE.	
Philippine Manganese Co.	Manila	Ilocos Norte.

FOURTH PHILIPPINE LEGISLATURE, }
First Session. } H. No. 632.

[No. 2719.]

AN ACT TO PROVIDE FOR THE LEASING AND DEVELOPMENT OF COAL LANDS IN THE PHILIPPINE ISLANDS.

Be it enacted by the Senate and House of Representatives of the Philippines in Legislature assembled and by the authority of the same:

SECTION 1. Coal-bearing lands of the public domain in the Philippine Islands shall not be disposed of in any manner except as provided in this Act.

The Government shall be understood to reserve its right to any coal deposits on land of the public domain reserved for provincial, municipal or school purposes, or granted in any manner to provinces or municipalities, or the usufruct of which has been granted to private corporations, and likewise on lands of the public domain or granted under the provisions of the Public Land Act, if at the time of the disposition thereof the Government was not aware of the existence of such coal deposits.

SEC. 2. Any unreserved, unappropriated coal-bearing public land may be leased by the Secretary of Agriculture and Natural Resources in blocks or tracts of not less than four hundred nor more than twelve hundred hectares each, in such manner as may, in the opinion of the Secretary of Agriculture and Natural Resources, allow the economic exploitation of the coal. The lease may be granted to any person above the age of twenty-one years who is a citizen of the Philippine Islands or of the United States, or to any association of such persons, or to any corporation organized under the laws of the Philippine Islands: *Provided,* That a majority of the stock of such corporation shall at all times be owned and held by citizens of the United States or the Philippine Islands: *And provided further,* That any person, association, or corporation qualified to become a lessee under this Act, and owning any located or patented claim to any coal lands in the Philippine Islands, may, within one year from the passage of this Act, enter into an arrangement with the Secretary of Agriculture and Natural Resources whereby such claim shall be fully relinquished to the Government as a condition precedent to acquiring a lease under the provisions of this Act, said owner, in consideration of such relinquishment, being given the preference in applications for leasing contiguous tracts. The Department Secretaries, acting jointly, are authorized to pay a compensation in exchange for such relinquishment if they see fit.

SEC. 3. Leases under the provisions of this Act shall be issued upon publication, in the manner and subject to the rules prescribed by the Secretary of Agriculture and Natural Resources, for periods of not more than fifty years each, subject to renewal on such terms and conditions as may be authorized by law at the time of such renewal, and no such lease shall be assigned or sublet except with the consent of the Secretary of Agriculture and Natural Resources, and in this case only to persons and associations of persons or corporations having the qualifications required of lessees. Every lease shall contain a clause by which the lessee shall bind himself to comply with the rules and regulations issued by the Secretary of Agriculture and Natural Resources for the purpose of insuring the exercise of reasonable diligence, skill, and care in the operation of said property and for the prevention of undue waste, together with such other rules and regulations as the said Secretary may make for the protection of the interests of the Government and for the promotion of the public welfare. For the privilege of mining, extracting, and disposing of the coal in the lands covered by his lease, the lessee shall pay to the Government of the Philippine Islands, through the Collector of Internal Revenue, such royalties as may be specified in the lease, which shall not be less than ten centavos per ton of one thousand and sixteen kilos, said royalties to be due and payable at the end of each month succeeding that of the shipment of the coal from the mine, and an annual rental, payable in advance on the date of the approval of the lease and thereafter at the beginning of each year, on the lands covered by such lease, at the rate of two pesos and fifty centavos per hectare for the first year and five pesos per hectare for each and every year thereafter during the continuance of the lease: *Provided*, That such rental for any year shall be credited against the royalties as they accrue for that year.

SEC. 4. Any person, association, or corporation holding a lease of coal lands under this Act may, with the approval of the Secretary of Agriculture and Natural Resources and through the same procedure and upon the same terms and conditions as in the case of an original lease under this Act, secure a further or new lease covering additional lands contiguous to those embraced in the original lease, but in no event shall the total area embraced in such original and new leases exceed in the aggregate twelve hundred hectares: *Provided*, That upon satisfactory showing by the lessee that all of the workable deposits of coal within the limits of the land leased will be exhausted or removed within three years thereafter, the Secretary of Agriculture and Natural Resosurces may, within his discretion, lease to such lessee an additional tract of land or coal deposits, which, including the coal area remaining in the original lease, shall not exceed twelve hundred hectares, through the same procedure and subject to the same requirements as in case of the original lease.

SEC. 5. Subject to the approval of the Secretary of Agriculture and Natural Resources, lessees holding under leases small blocks or areas may consolidate their said leases or holdings so as to include in a single holding a total of not to exceed twelve hundred hectares, provided all lessees have at the time of such consolidation complied individually with all their obligations towards the Government.

SEC. 6. Each lease shall be for such leasing block or tract of land as may be offered or applied for, not exceeding in area twelve hundred hectares of land, and no person, association, or corporation, except as hereinafter provided, shall be permitted to take or hold any interest as a stockholder or otherwise in more than one such lease under this Act, and any interest held in violation of this proviso shall be forfeited to the Government by appropriate proceedings instituted by the Attorney-General for that purpose in any court of competent jurisdiction, except that any such ownership and interest hereby forbidden which may be acquired by descent, will, judgment, or decree may be held for two years, and not longer, after its acquisition.

SEC. 7. Any person who shall purchase, acquire, or hold any interest in two or more such leases, except as herein provided, or who shall knowingly purchase, acquire, or hold any stock in a corporation having an interest in two or more such leases, or who shall knowingly sell or transfer to one disqualified to purchase, or, except as in this Act specifically provided, disqualified to acquire, any such interest, shall be deemed guilty of a felony, and upon conviction shall be punished by imprisonment for not more than three years and by a fine not exceeding two thousand pesos: *Provided*, That any such ownership and interest hereby forbidden which may be acquired by descent, will, judgment, or decree may be held two years after its acquisition and not longer, and in case of minority or other disability, during such minority or disability and for two years after majority has been reached or the disability disappeared.

SEC. 8. Any director, trustee, officer, or agent of any corporation holding any interest in such a lease, who shall, on behalf of such corporation, act in the purchase of any interest in another lease, or who shall knowingly act on behalf of such corporation in the sale or transfer of any such interest in any lease held by such corporation to any corporation or individual holding any interest in any such a lease, except as herein provided, shall be guilty of a felony and shall be subject to imprisonment for a term of not exceeding three years and a fine of not exceeding two thousand pesos.

SEC. 9. If any of the lands or deposits leased under the provisions of this Act shall be subleased, trusteed, possessed, or controlled by any device permanently, temporarily, directly, indirectly, tacitly, or in any manner whatsoever, so that they form part of or are in anywise controlled by any combination in the form of an unlawful trust, with consent of lessee, or form the subject of any contract or conspiracy in restraint of trade in the mining or selling of coal, entered into by the lessee, or of any holding of such lands by any individual, partnership, association, corporation, or control, in excess of twelve hundred hectares, the lease thereof shall be forfeited by appropriate court proceedings.

SEC. 10. That in order to provide for the supply of strictly local and domestic needs for fuel the Secretary of Agriculture and Natural Resources may, under such rules and regulations as he may prescribe in advance, issue to any applicant qualified under section two of this Act a limited license or permit granting the right to prospect for, mine, and dispose of coal belonging to the Government on specified tracts not to exceed four hectares to any one person or association of persons in any one coal field for a period of not exceeding ten years, on such conditions not inconsistent with this Act as in his opinion will safeguard the public interest, without payment of royalty for the coal mined or for the land occupied, if he, in his discretion, consider this necessary: *Provided*, That the acquisition or holding of a lease under the preceding sections of this Act shall be no bar to the acquisition, holding, or operating under the limited license in this section permitted. And the holding of such a license shall be no bar to the acquisition or holding of such a lease or interest therein.

SEC. 11. Any lease, entry, location, occupation, or use permitted under this Act shall reserve to the Government the right to grant or use such easements in, over, through or upon the land leased, entered, located, occupied, or used as may be necessary or appropriate to the working of the same or other coal lands under Government permit, and for other purposes: *Provided,* That the Secretary of Agriculture and Natural Resources in his discretion, in making any lease under this Act, may reserve to the Government the right to lease, sell, or otherwise dispose of the surface of the lands embraced within such lease under existing law or laws in so far as said surface is not necessary for use by the lessee in extracting and removing the deposits of coal therein. If such reservation is made, it shall be so determined before the offering of such lease. The Secretary of Agriculture and Natural Resources, during the life of the lease is authorized to issue such permits for easements herein provided to be reserved, and to permit the use of such other public lands as may be necessary for the construction and maintenance of coal bunkers or other works incident to the mining or treatment of coal, which lands may be occupied and used jointly or severally by lessees or permittees, as may be determined by the Secretary of Agriculture and Natural Resources.

SEC. 12. Any such lease may be forfeited and canceled by appropriate proceeding in a court of competent jurisdiction whenever the lessee fails to comply with any provision of the lease or of general regulations promulgated under this Act; and the lease may provide for the enforcement of other appropriate remedies for breach of specified conditions thereof.

SEC. 13. Any lessee under this Act may exercise the right of eminent domains for the purpose of acquiring such right of way as may be necessary in connection with the operations contemplated by said lease.

SEC. 14. The Government of the Philippine Islands, recognizing the relation of the coal resources of the country to its general welfare, reserves the right to work and exploit coal mines itself or organize and promote coal mining corporations by becoming either exclusive or majority stockholder therein and in such enterprises shall not be bound by any provision in this or other laws restricting holdings either territorially or otherwise.

SEC. 15. Effective upon the passage of this Act there shall be assessed and collected by the Collector of Internal Revenue, an annual tax of two thousand pesos on each block or tract of four hundred hectares, or fraction thereof, of coal lands owned by any person, firm, association, or corporation, and a tax of four centavos per ton of one thousand and sixteen kilos on each ton of coal extracted therefrom, said taxes to be payable at the same time, in the same manner and under the same conditions as provided in section three hereof for the payment of rentals and royalties. The taxes herein provided shall be in lieu of all other taxes of whatever nature. In case of delinquency in the payment of either said annual tax or specific tax continuing for sixty days from the time when the same may be due or payable, the same remedies for enforcement of this section, by sale of the lands, or otherwise, may be pursued as in the ordinary procedure for nonpayment of land taxes.

SEC. 16. All statements, representations, or reports required, unless otherwise specified, by the Secretary of Agriculture and Natural Resources under this Act, shall be upon oath and in such form and upon such blanks as the Secretary of Agriculture and Natural Resources may specify, and any person making false oath, representation, or report shall be subject to punishment as for perjury.

SEC. 17. The Secretary of Agriculture and Natural Resources is authorized to prescribe the necessary and proper rules and regulations and to do any and all things necessary to carry out and accomplish the purposes of this Act; and under his immediate and direct control, the Bureau of Lands shall have charge of the survey, registration, and administration of said lands, and the Bureau of Science of the geological work.

SEC. 18. The sum of thirty thousand pesos is hereby appropriated, out of any funds in the Insular Treasury not otherwise appropriated, to the end that the Secretary of Agriculture and Natural Resources may have the Director of Lands proceed to the survey and legal subdivision of all coal-bearing lands of the public domain and the determination of the ownership thereof, in accordance with section sixty-one of the Public Land Act.

SEC. 19. Act Numbered Eleven hundred and twenty-eight and all Acts and parts of Acts in conflict herewith are hereby repealed.

SEC. 20. This Act shall take effect on its approval by the President of the United States.

Approved, May 14, 1917.

DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES.

REGULATIONS GOVERNING THE LEASING AND DEVELOPMENT OF COAL LANDS IN THE PHILIPPINE ISLANDS, AS PROVIDED IN ACT NUMBERED TWENTY-SEVEN HUNDRED AND NINETEEN.

1. *Definition of coal-bearing lands to be reserved.*—By coal-bearing lands of the public domain shall be understood those which, after proper exploration and study by the Bureau of Science, have been determined to be capable of being worked profitably. In the absence of the certification by the Director of the Bureau of Science, a sworn statement by the applicant that the land applied for contains valuable deposits of coal may be accepted in lieu of said certification. It shall be understood that the right mentioned in Section 1 of Act No. 2719 is reserved unless the Secretary of Agriculture and Natural Resources shall state otherwise in writing.

2. *Classification of coal lands.*—For the purposes of Sec.[s]. 1, 2, 3, and 15 of the Act, the following classification is established:

Class A. Coal deposits on unreserved or unappropriated public land.

Class B. Coal deposits on lands reserved for Insular, provincial, municipal, or school purposes, or granted in any manner, or the usufruct of which has been granted to provinces, municipalities or private corporations, but at the time of their disposition the Government was not aware of the existence of the deposits.

Class C. Coal deposits on located and patented lands.

Evidence of coal deposits on lands claimed as private must be registered in the Bureau of Lands within six months after the publication of these regulations in the Official Gazette, or within six months after the discovery of said evidence, in order that the Director of Lands may determine the title to said coal deposits.

3. *Acquisition, reservation, survey, subdivision, and registration of coal lands.*—No location or relocation of a coal claim is legal subsequent to May 14, 1917, when Act No. 2719 was approved. All patents for locations made prior to May 14, 1917, must be obtained within the time prescribed in Act No. 1128, otherwise the property reverts to the Government.

By order of the Secretary of Agriculture and Natural Resources and under the Director of the Bureau of Lands, lands in Class A shall be surveyed and subdivided into tracts of 400 hectares each, and as nearly as possible rectangular in shape.

When coal deposits have been found in lands of Class B, which, by a report from the Bureau of Science, are shown to be more valuable for their mineral contents than for the purposes for which they have been reserved or granted, said holders or grantees will be notified of the discovery and of the intentions of the Government, and will be given a reasonable time within which to file their claims and rights with the

Secretary of Agriculture and Natural Resources, such claims and rights to be supported by legal evidence. The Secretary of Agriculture and Natural Resources shall render a decision as to the disposition of said lands and the holders shall be given a reasonable time within which to comply with his decision. The cancellation of said reservations or grants shall be in accordance with the provisions of the law.

The holders or grantees shall have the first right of application for leasing these and contiguous areas after the demands of holders of lands of Class C have been satisfied. If the holders or grantees do not apply for a coal lease covering their holdings, the next right shall fall to any prior lessee of contiguous coal lands who quit operation with the consent of the Secretary of Agriculture and Natural Resources.

In [If] the Secretary of Agriculture and Natural Resources desires to consider the payment of a compensation in exchange for the relinquishment of any coal lands of Class C, the said Secretary may appoint a committee to report upon the actual as well as the declared and assessed value of the improvements on said located or patented claims, and upon any other pecuniary loss that would accrue to the holder or grantee by relinquishment of said claims to the Government. Upon receipt of the report, the Secretary of Agriculture and Natural Resources shall forward same, together with his recommendation, to the Department Secretaries for their joint action.

4. *Leases.*—Lease applications may be made either upon lands already surveyed and registered by the Bureau of Lands or upon unsurveyed and unregistered. If the application refers to surveyed land, it is sufficient that the applicant should state thereon the number of the survey and the municipality and province where it is made. If it refers to unsurveyed lands, the applicant should accompany the application with a sketch of the boundaries of and improvements on the land. The Director of Lands, upon receiving this application, shall immediately order a survey thereof at the expense of the applicant, after which the land shall be duly registered. The Director of Lands may require a deposit from the applicant to cover the cost of the survey.

After proper survey, subdivision and registration of the coal lands, the Director of Lands, under authority of the Secretary of Agriculture and Natural Resources, shall publish in the Official Gazette, and at least in one English and in one Spanish newspaper, for a period of three weeks, all areas that are opened to lease, or areas upon which leases have been applied for. Notices concerning said areas shall be posted in a conspicuous place in the provincial and municipal government buildings of the province and municipality in which the land is located.

The Director of the Bureau of Lands shall from time to time prepare such blank forms as are necessary, with the approval of the Department head. The Director of Lands, with the approval of the Department head, shall also prepare and award the leases in accordance with the terms of Act No. 2719 and these regulations. Compliance with the rules and regulations of the Secretary of Agriculture and Natural Resources shall be a provision of the lease.

An application for a lease of coal-bearing land must be executed under oath and filed with the Director of the Bureau of Lands, and must show the following facts: The age, citizenship and post-office address of the applicant; the location of the land, showing the province, municipality, and barrio in which the same is situated, and as accurate a description as may be given, showing the boundaries of the land, having reference to natural objects and permanent monuments, if any; a statement as to whether the land contains any improvements or evidences of settlement and cultivation, and such other information as the Secretary of Agriculture and Natural Resources may desire. Corporations and associations shall be required to file evidence of their legal existence and authority to transact business in the Philippine Islands. The Director of the Bureau of Lands shall require of an applicant a bond subject to forfeiture in case of nonfulfillment of the terms of the lease. A minimum annual investment will be required in each individual lease.

Any interest held in violation of sections 6 and 7 of Act No. 2719 which provide that "No person, association, or corporation," etc. "shall be permitted to take or hold any interest as a stockholder or otherwise in more than one such lease," and that any "ownership and interest hereby forbidden which may be acquired by descent, will, judgment, or decree may be held for two years after its acquisition and not longer, * * *," or in violation of any other provision of said Act 2719 shall be forfeited to the Government by appropriate proceedings instituted by the Attorney-General for that purpose in any court of competent jurisdiction.

Consolidation of leases.—It is desirable that in so far as possible leases consolidated under section 5 of Act No. 2719 be contiguous or at least in the same province. Other request for consolidation shall be considered only when economy can be effected, or when such consolidation will promote the public welfare.

Royalties and rentals.—Royalties and rentals shall be governed by the rules of the Bureau of Internal Revenue.

The Director of the Bureau of Lands with the applications for leases shall receive bids with regard to royalty for the privilege of mining, extracting, and disposing of the coal of the lands to be covered by any given lease that the lessee shall pay to the Collector of Internal Revenue of the Government of the Philippine Islands. No bid shall be received for less than 10 centavos a ton of 1,016 kilos, nor without a statement of the work that the bidder will guarantee to perform annually. When the highest bid has been ascertained, a lease shall be issued to the one having preference in application. If persons so entitled do not apply for lease under these conditions within forty days, the lease shall be awarded at the highest bid to the person or corporation best qualified, in the opinion of the Director of Lands, to carry out the provisions of the lease. In the case of a former grantee or legal occupant of the land who has not been reimbursed, any improvements belonging to him shall be taken into consideration in connection with any bid from him for a lease.

Subleases.—Subleases will in general not be granted. When a sublease is granted the original lessee shall be responsible for the compliance of the sublessee with all the terms and conditions under which the original lease has been granted, and the sublessee shall be subject to all regulations promulgated in connection with leases, and is also responsible for the payment of taxes, rentals, or royalties. The Government shall not be made responsible for any damage done to sublessee in case of forfeiture or cancellation of the original lease or the failure of the original lessee to comply with the provisions of Act 2719 or the rules and regulations prescribed by the Secretary of Agriculture and Natural Resources.

Extension of leases.—Any person, association, or corporation holding a lease may, with the approval of the Secretary of Agriculture and Natural

Resources and through the same procedure and upon the same terms and conditions as in the case of the original lease, secure a further or new lease covering additional lands contiguous to those embraced in the original lease, to give a total not exceeding that allowed by law.

In extending a lease under the provisions of section 4 of Act No. 2719, the procedure provided for a regular lease shall be followed.

Colliery operations.—The lessee and the superintendents employed by him shall be responsible that proper precautions are taken and instructions given to guard against spontaneous combustion, gob-fires, open pits, fire damp, to secure safety escapes and ventilation in the mine, and to avoid other dangers. For this purpose, all operators must comply with all instructions and rules which the Secretary of Agriculture and Natural Resources shall publish from time to time and be made a part of these regulations.

Inspectors.—All operators must give assistance and entrance to all surface and underground workings to such inspectors as may be sent by Directors of the Bureau of Science and of the Bureau of Lands, and such others as may be designated by the Secretary of Agriculture and Natural Resources.

The Secretary of Agriculture and Natural Resources may prohibit any practice or process of operation that in his opinion may result in undue waste of coal, or that will decrease the safety of the workers.

Right to quit.—If after one year's work the lessee can show to the Secretary of Agriculture and Natural Resources that the coal can not be mined at a profit, the latter can direct the Director of Lands to cancel the lease after proper application has been filed and approved by the Secretary of Agriculture and Natural Resources. In this case the lessee may remove whatever improvements he has placed upon the property within such reasonable time as the Secretary of Agriculture and Natural Resources might fix.

Easements.—The Government shall reserve the right to grant or use such easements in, over, through or upon the land leased, occupied, or used as may be necessary or appropriate to the working of the same or other coal lands under Government permit and for other purposes. During the life of the lease the Secretary of Agriculture and Natural Resources will issue permits for the use of such other public land as may be necessary for the construction and maintenance of mills bunkers, or tipples, and necessary plant, equipment. The right to cut timbers within such reserved area shall be governed by the rules and regulations issued by the Bureau of Forestry.

Surface rights.—Unless otherwise expressly specified, the Secretary of Agriculture and Natural Resources, in making any lease, reserves to the Government the right to lease, sell, or otherwise dispose of the surface of the lands embraced within such lease so far as said surface is not necessary for use by the lessee in extracting and removing the deposits of coal therein.

Reports and maps.—In accordance with section 16 of Act No. 2719 the lessee shall make the following reports in such manner as the Secretary of Agriculture and Natural Resources shall prescribe.

One daily report, a copy of which shall be sent to the Collector of Internal Revenue, which may be consulted and be taken up by any authorized inspector when on inspection, and which shall state the condition of the mine as to working rooms, tunnels, shafts, etc.; number of men at work, tons of coal mined and brought to the surface, coal consumed, etc.

One monthly report, copies of which shall be sent to the Bureaus of

Science and Internal Revenue and to the Provincial Treasurer, stating the general conditions of the mine, area developed and worked, monthly output and shipment, timber cut and used, other improvements introduced in the operation, etc.

Each lessee must have an accurate map of the area worked drawn on a scale of 1:1000, or of approved scale, and referred to a corner monument of the property covered by the lease. The lessee shall draw on this map all weekly progress of underground and surface working and shall send a blue print to the Bureau of Science at the end of each quarter of the calendar year.

5. *Operations of private coal lands.*—Owners of private coal lands shall be subject to the same terms, conditions and penalties as regards to colliery operations, inspections, reports and maps, etc., as in the case of operators of leases.

6. *Government ownership.*—Any Government coal mines or incorporations in accordance with section 14 of Act No. 2719 shall comply with the above provisions regarding colliery operations, inspections, maps, etc.

7. *Prospecting.*—Any limited license or permit granting the right to prospect for, mine, and dispose of coal belonging to the Government as provided under section 10 of Act No. 2719 shall be subject to the following additional terms and conditions:

Not more than one prospecting ground shall be issued to any single applicant.

Not less than ₱200 worth of work shall be done annually on the development of the ground.

The applicant shall have the right to sell the coal mined from the land after he has signed a sworn statement that such coal has been extracted only from the ground granted to him, and upon payment of an internal revenue tax of 50 centavos per ton of 1,016 kilos. Timber used in the development of a prospect must first be licensed by the Bureau of Forestry. The workings shall at any time be open to the inspection of any authorized inspector.

Abandonment of work for more than one year or a violation of regulations shall be sufficient cause to cancel the grant.

The applicant must designate his authorized agent on the ground during working periods and sign a sworn statement declaring that he is not a representative nor working in the interest of any person, association, or corporation unqualified by Act No. 2719 to acquire such grant.

The holder of such a license shall render a semiannual report at the middle and at the end of each calendar year similar to the monthly report required of a lessee, copy of which shall be furnished to the Bureaus of Science and Internal Revenue. When any report is six months overdue, the license shall be canceled.

Approved.

G. APACIBLE,
Secretary of Agriculture and Natural Resources.

MANILA, *August 15, 1917.*

Fig. 1. Gumaus dredge in operation.

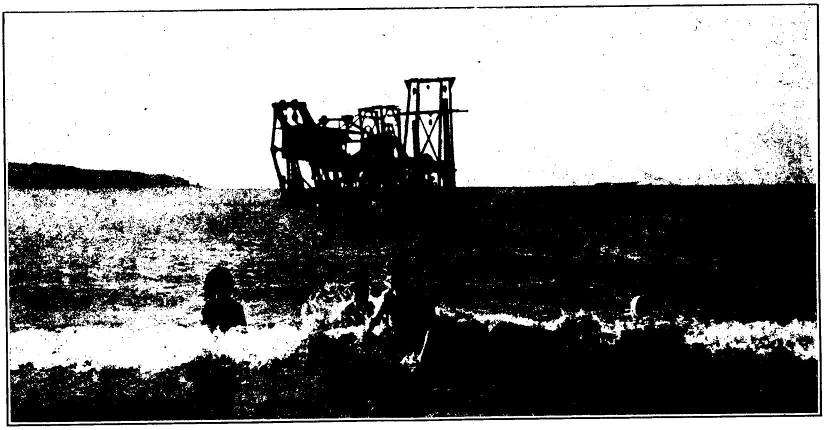

Fig. 2. Gumaus dredge, sunk in Gumaus Bay, December, 1917.

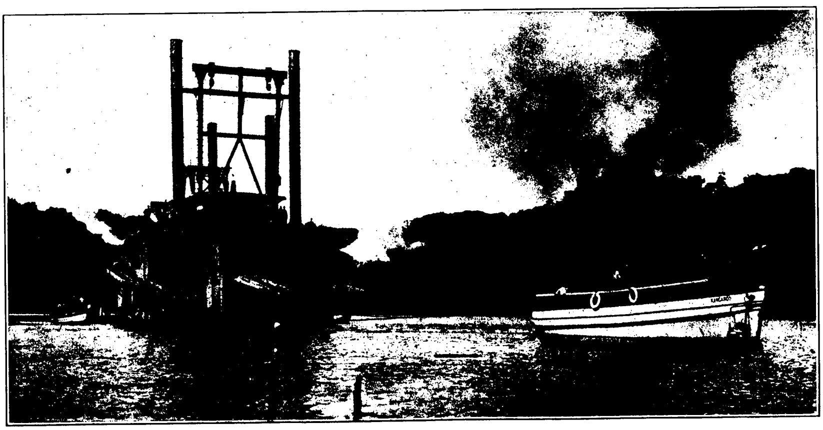

Fig. 3. Malaguit dredge, working in Malaguit River.

PLATE 2.

Fig. 1. Clearing top of hill previous to quarrying.

Fig. 2. Shore line outcrop. Bowlders of pure iron ore.

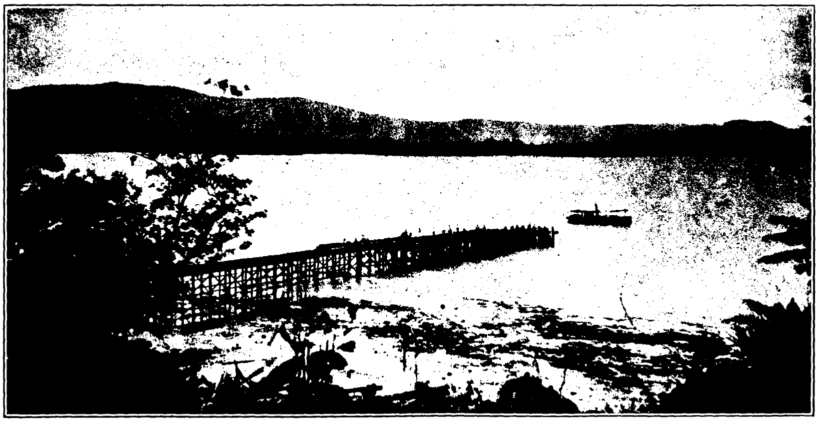

Fig. 3. Pier landing, Calambayanga, Ambos Camarines.

PLATE 3.

Fig. 1. Asbestos quarry near Bangui, Ilocos Norte.

Fig. 2. Asbestos products of Ilocos Asbestos Products Co.

Fig. 3. Anti-Tuberculosis Society houses.

PLATE 4.

Fig. 1. Vein in place.

Fig. 2. Hand jig.

Fig. 3. An open-hearth furnace.

PLATE 5.

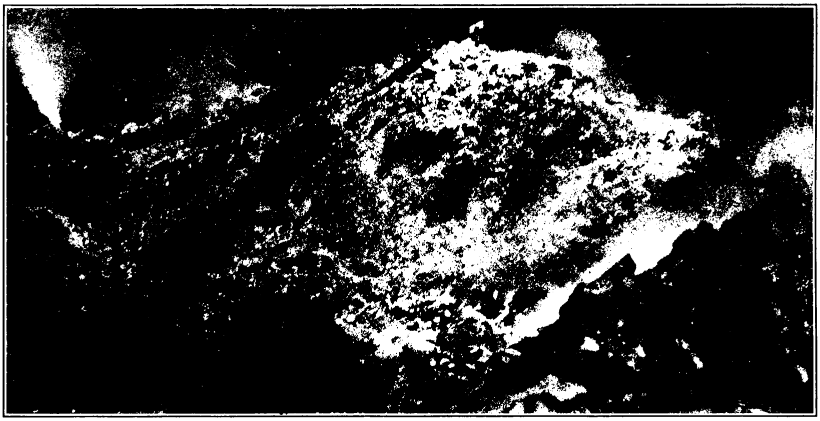

Fig. 1. Sulphur deposit on Mount Azufre, Occidental Negros.

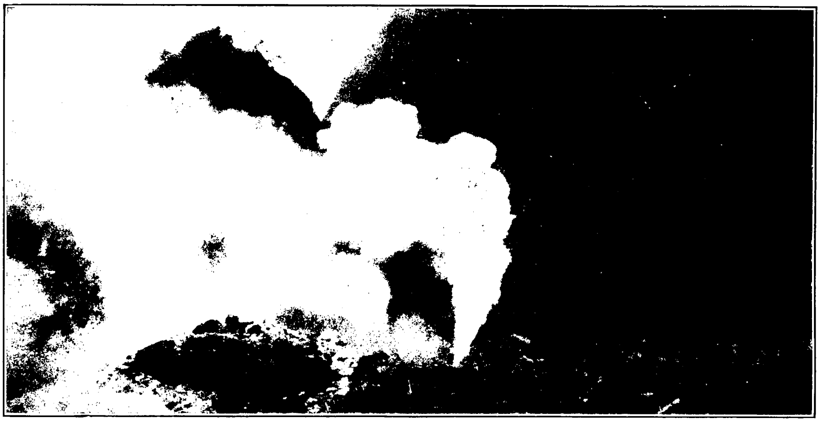

Fig. 2. Sulphur deposit, showing active solfataras.

Fig. 3. Sulphur in piles around dead solfataras.

PLATE 6.

Fig. 1. Laborers at work, Lucio asphalt mine.

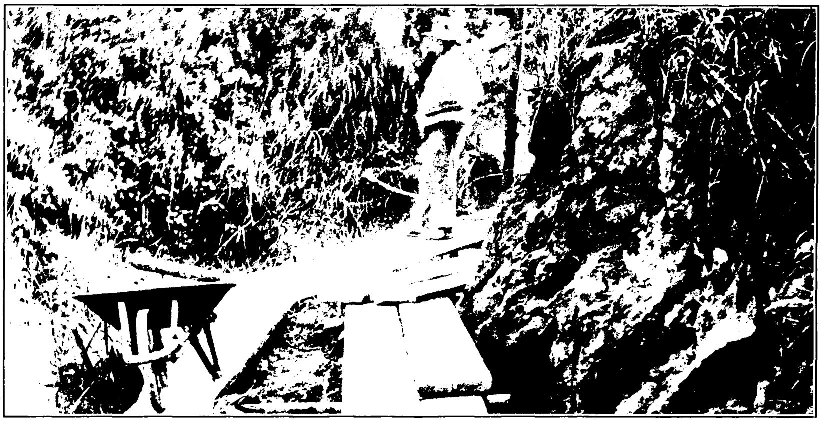

Fig. 2. Lucio mine, showing small vein at right side.

Fig. 3. Asphalt ready for shipment.

PLATE 7.

Fig. 1. Asbestos mine in Ilocos Norte.

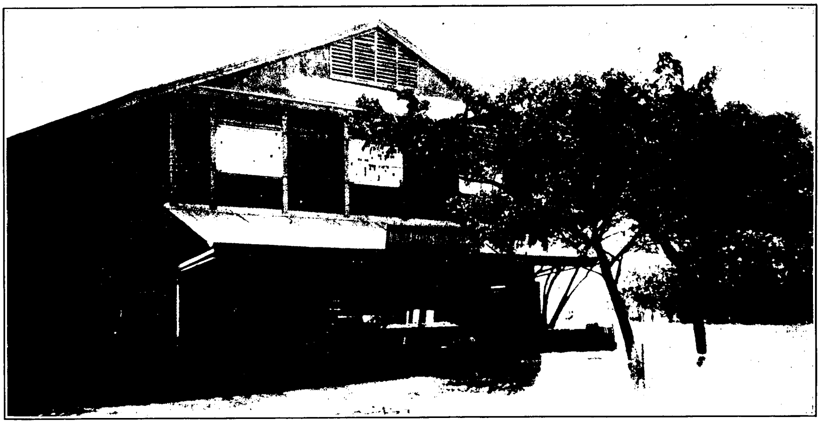

Fig. 2. Exterior of asbestos-products factory, Santa Ana, Manila.

Fig. 3. Interior of asbestos-products factory, Santa Ana, Manila.

PLATE 8.

GOVERNMENT OF THE PHILIPPINE ISLANDS
DEPARTMENT OF AGRICULTURE AND NATURAL RESOURCES
BUREAU OF SCIENCE

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1919 AND 1920

ISSUED BY THE DIVISION OF MINES
BUREAU OF SCIENCE

MANILA
BUREAU OF PRINTING
1922

184098

PLATE 1. BENGUET CONSOLIDATED MILL, ANTAMOK, MOUNTAIN PROVINCE, LUZON.

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THE DIVISION OF MINES OF THE BUREAU OF SCIENCE

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ILLUSTRATIONS

THE MINERAL RESOURCES OF THE PHILIPPINE ISLANDS FOR THE YEARS 1919 AND 1920

INTRODUCTION

By Elmer D. Merrill

From 1908 to 1916, inclusive, this publication was issued annually; but, owing to local conditions and the depletion of the technical staff of the Division of Mines, the annual issue was discontinued in 1917 and a biennial issue was commenced in 1918 covering the period 1917–1918. The present issue covers the second biennial period 1919–1920.

Like the preceding issues of this series the present number is planned to give definite information regarding the status of and development in the mining industry, in its broadest sense, in the period covered. With the return of Dr. Warren D. Smith in 1920, formerly chief of the Division of Mines, much of the work formerly done in the division has been rehabilitated. Most of the actual work in preparing this issue has been accomplished since the return of Doctor Smith in September, 1920, so that delay in completion of the manuscript has been unavoidable.

An article on coal in the Philippines was prepared for this issue, but on account of the absolute necessity for curtailment in expenditures this has been eliminated. However, essentially the same material appears in the October and November numbers of the Trans-Pacific for 1921, an American trade and technical journal published in Tokio, Japan.

GENERAL SURVEY

By WARREN D. SMITH

Of the three basic industries—mining, agriculture, and forestry (to which is sometimes added a fourth, fisheries), the tripod directly supporting our material civilization and indirectly our whole physical, intellectual, and moral life—the first has been the tardiest in development in the Philippines. Although the industry has advanced each year, still we find to-day one or two very successful companies, a few struggling ones, and a host of others that were stillborn. This backwardness in Philippine mineral development is due to several factors, and the Government cannot be blamed for all of it. What those other factors are we shall come to in later paragraphs. The Government's failure to encourage the mining industry to the fullest extent cannot be attributed so much to a lack of desire to assist as to the fact that there are other claims upon the support of the Government, and to the further fact that the Government has not realized the necessity of things which to men in the industry itself appear to be self-evident. The chief of the Division of Mines is the main connecting link between the Government and the mining industry; therefore, it is my duty to report the true status of the situation, without reservations. In any governmental shortcomings I do not wish to evade my own share of responsibility.

A specific case may be cited. The gold-mining industry of Benguet depends absolutely upon cheap power—water power. A large power project on Agno River now contemplated by the Government should have been realized years ago, as it would have made possible the consolidation and successful working of a half dozen or more low-grade properties now lying idle. The Government is losing every day a by no means inconsiderable direct revenue as a result of this not being done, and the country is losing indirectly by this potential wealth not being made available.

American capital, with good reason, has for a number of years been chary about going outside the United States to seek investment; so that the industry here has depended and must, to a large extent, still fall back upon New Zealand, Australian, and China Coast capital. Our dredging industry has been largely in the hands of New Zealanders ever since it started.

There are indications that the Filipinos are becoming aware of their long neglect of this important branch, and Filipino prospectors are beginning to come in more and more with their finds. Although quite a number of them are engaged in crude mining for coal, gold, and iron in a small way, in a few localities, there is no private company of Filipinos engaged in the business on a large scale. It is true that the Philippine Government, the majority of whose responsible officials are Filipinos, is now sponsoring several national mining projects whose success cannot be predicted owing to very serious difficulties of a fundamental nature; but these projects have not yet passed the development stage.

It has been said many times that mining in the Philippines is not a "poor man's game." This is quite true except in gold mining, in which it is possible to make "better than wages" with very limited capital. There are not only a few Americans engaged in this sort of mining, but hundreds of natives get a livelihood by panning the streambeds. Aside from the great inherent difficulties attending all large industrial enterprises in the Tropics, most of our metalliferous deposits are low-grade and refractory. There are exceptions, of course, such as the rich gold placers of the Paracale district, which appear now to be almost exhausted, and the lode being worked by the Benguet Consolidated Mining Company.

The Philippine mineral products, in order of their money value production, are (1) gold; (2) salt; (3) stone; (4) coal; (5) sand and gravel; (6) lime; (7) clay (pottery); (8) clay (brick and tile); (9) iron ore; (10) mineral waters; (11) bituminous rock; (12) silver; (13) sulphur.

The location of the principal mineral deposits is shown on the map, Plate 2.

GOLD

The gold production is still the highest of all the mineral products; and the industry remains almost entirely in the hands of Americans, with some assistance from Australians and New Zealanders, who are first cousins to Americans in the mining business.

It is noteworthy that, whereas in other countries the gold mining business has fallen off greatly, here in the Philippines we have maintained a steady, though not large, output of the yellow metal, the production for 1920 being only a few ounces less than that in the banner year of 1916, when gold was actually worth more than it is now.

The Aroroy district still leads the others in gold production owing to the continuous operation of its two mines, the Colorado and the Syndicate. The Benguet, with its single large producer, alone almost equaling the combined production of the two in the Aroroy district, is a close second. Paracale, once in the limelight as a result of its rather remarkable, though small, dredging field, is to-day a mere reminiscence of its former self—only one dredge and a small ten-stamp mill are operating.

The Benguet Consolidated, in Antamok Valley, has steadily paid dividends of from 25 to 35 per cent. At the present writing, the values on the lowest level of the mine are most encouraging, indicating possibly secondary enrichment in the vein. This mine is fast coming to be recognized as one of the notable small gold mines of the world. The vein is a quartz (and some calcite) filling in a fault-brecciated zone nearly 75 meters wide between andesite walls with two strong veins, one on the hanging, the other on the foot wall, with low-grade, mineralized "country" between. The mineralization in this lode is undoubtedly connected with the quartz-diorite intrusive mass, a short distance to the east. It is noteworthy that the successful producers all around the Pacific are generally associated with a rock very similar to this. This is the case in Korea, Alaska, and California. Gold deposits in the later andesite appear to be neither so rich nor so persistent. A study of the geology of these deposits years ago indicated what might be expected of them, and early predictions by Government geologists at that time have been fully substantiated.

The value of the gold produced from Philippine mines during 1920 was approximately 2,500,000 pesos; of this the Benguet Consolidated turned out 1,068,892.30 pesos.

SILVER

Until recently silver unalloyed with gold or in galena was not known to have been found anywhere in the Philippines; but from the Acupan camp of the Baguio district native silver has recently been reported. However, most of the silver produced in the Philippines comes alloyed with gold. Some ores carry as much as 5 ounces of silver to 1 of gold. There is also a very appreciable amount of silver in the lead ores of Marinduque and Cebu, but these deposits are not now being worked. No large silver deposits have been discovered in the Philippines as a recent Federal commerce report, published in the United

States, has indicated. This report is due to the garbling of statements made in an early press bulletin of the Bureau of Science.

IRON

There were nearly 20,000 metric tons of iron ore mined in 1919. The production for 1920 fell considerably below this, amounting to only 116 tons. The reason for this is that the Calambayanga deposits, which previous to that time had been mined by Japanese interests, lay idle. This was one of the "war babies" that died from lack of nourishment at the close of the war. The specific reasons for the cessation of this undertaking are not known, but it is presumed that the falling market and the export tax of 2 pesos per ton made the mining of this ore prohibitive. Therefore, at the present time the only production is in the Angat district in Bulacan Province where, during 1920, 83 metric tons of pig iron were made from the high-grade hematite of that region. The production in this district is entirely in the hands of Filipinos, who are using the very crude, but also very cheap, methods of the Chinese. The product is of such high grade, owing to the excellence of the ore and the use of charcoal, that the plowshares cast from this material are prized above even the imported steel plows. Messrs. Pratt and Dalburg, who made a thorough study of this region in 1912, estimated the probable iron ore reserve in this region at 1,200,000 tons.

In Surigao Province, Mindanao, on Dahikan Bay, there is what appears to be an enormous deposit of lateritic iron ore, which in many ways resembles the Cuban deposits at Nipe Bay. Messrs. Pratt and Lednicky, who surveyed the Surigao deposits in 1915, estimated the iron ore reserves in this field to be 500,000,000 tons. The deposit was set aside as a Government reservation by an executive order of the Governor-General in 1915, and it is this which the recently created National Iron Company intends to exploit. If this deposit is worked, the logical place for the smelting operations will be somewhere near the city of Cebu, on Cebu Island, as most of the good seams of coking coal known in the Islands are located there, and the rule generally, the world over, is that "iron goes to coal." Cebu has other recommendations as a smelting point; the largest supply of labor is there, and it is very favorably situated geographically and commercially.

COPPER

There has been practically no production of this metal during American occupation, although development work on the old

Mancayan properties continues. Many examinations of this deposit have been made, and they reveal a fairly extensive body of low-grade enargite. Practically the only economical solution of the disposition of this ore appears to be exportation to some neighboring country, where smelters are already in operation. The copper market is too uncertain, and the local obstacles, such as transportation, lack of timber, cost of smelter, labor, etc., are so great as hardly to be easily overcome.

COAL

In connection with iron coal should be next considered. It is extremely gratifying to see the coal industry coming into its own in the Philippines after a century of failures. Again we have the war to thank for the stimulus needed. There is some coal on practically every large island of the group, but there are ten localities of first importance. These are:

Batan Island.—This is the site of the largest producing coal mine in the Philippines.

Gotas-Butong, on Dumanquilas Bay, Mindanao.—This is the site of the principal workings of the National Coal Company. At Butong is a seam of semianthracite over 2 meters in thickness. In percentage of fixed carbon this is the highest grade of coal found anywhere in the Philippines. This coal is too hard to be burned alone in the grates of the interisland vessels and requires forced draft.

Cebu Island.—On this island are five important localities: (a) Mount Licos. (b) Cajumay-jumayan; some of the largest coal seams yet found in the Islands are located in this field; one is over 4 meters thick. (c) Mount Uling; the second largest and most successful of Philippine coal mines is located in this field. (d) Mananga River in the locality of Guila-guila; here is one of the few seams of coking coal known in the Philippines. (e) Toledo. There are apparently extensive coal deposits near Toledo on the western side of Cebu Island which are now being developed. In addition there are a score or more of native, small "Revocable Permit" mines scattered through this island.

Polillo Island.—There are deposits of excellent sub-bituminous coal of unknown extent, a few kilometers from the town of Burdeos.

Mindoro Island, at Bulalacao.—Several workable seams of unknown extent have been known here for many years. Some attempts to mine this coal were made during the Spanish régime.

Masbate Island, at Cataingan.—The largest producer of coal in the Philippines is the Philippine Coal Mining Company, on the eastern end of Batan Island. This company has been producing, until recently, over 300 tons a day. Just at present its production has fallen off somewhat.

The National Coal Company, as far as capital and equipment are concerned, is the largest coal undertaking in the Philippines and it has apparently ample coal reserves, but it is handicapped by difficulties inherent in nearly all projects of a business nature run by any government. To date this project, by which great store was set, has not been a success.

SALT

Among the nonmetallic minerals, salt takes first place, as is natural. Without salt, it would be hard to live. In one remote corner of Mindanao, which was visited by our engineers some years ago, this commodity was so valuable that a man could purchase a wife with a pound of it. Most domestic salt is produced from solar evaporation of sea water, this being a household industry. However, in some part of the Islands, particularly in northern Luzon, there are hot salt springs from which the natives secure a very considerable quantity of salt. These hot waters are also prized as curatives for skin troubles. The best-known salt springs in Luzon are at Mainit near Bontoc, and Asin near Buguias, both in the Cordillera Central.

STONE

Virtually all of the stone quarried in the Philippines is used either for concrete construction or for macadam roads, and only a small amount is used as building and ornamental stone.

The principal building stone in the Philippines is a volcanic tuff known as Meycauayan and Guadalupe stone. Many of the large and older public buildings in Manila are made of this material. It is a most admirable construction material for an earthquake country like this, as it is exceedingly tough, durable, and elastic.

The principal ornamental stone is Romblon marble, but this stone is not altogether free from small fissures and seams, which are unfavorable features. Coral limestone has been quarried in the past in many islands, notably Cebu, for construction material. Many churches are made of this material. Magellan's monument on Mactan Island is constructed of this stone. There is also an abundance of granitic rocks, such as diorite, which might be used, but these have been quarried only to a limited extent. One still sees in the older parts of Manila slabs of granite which have been imported from Hongkong. We have stone quite as good, though probably not so accessible, in many parts of the Philippines.

SULPHUR

Practically all the sulphur mined in the Philippines at present comes from Silay, Negros. Deposits of fair size are known on Camiguin Island, in the Babuyanes, north of Luzon, but the earlier mining operations there have now ceased. Around many of the old solfataras in the Philippines there are by no means inconsiderable deposits of sulphur which might be utilized, as was done in earlier days on Biliran Island and on the north coast of Leyte. The recent notable researches in the application of sulphur in scientific agriculture, made at the Oregon Agricultural College in the United States, indicate that the farmers of the future, even in the Philippines, will create a steady demand for this mineral. In fact, while at the University of Oregon, I was asked by commercial interests as to available supplies of sulphur in the Philippine Islands.

ASBESTOS

There was a very encouraging output of asbestos in 1919, but during the year 1920 mining operations on the old Dungon-Dungon Estate in Ilocos Norte ceased, and so the production for that year is less than for the previous one. The Ilocos Asbestos Products Company evidently has found the undertaking too expensive for its limited capital. This company has a factory in Manila where it has turned out some very valuable products in the nature of roofing material, pipe lagging, etc., and it is to be hoped that it will resume operations. The asbestos that has been mined has been largely of second and third grades, but some very fair specimens of chrysotile, as much as 2.5 centimeters in length, have been found.

CEMENT

The Rizal Cement Company at Binangonan on Laguna de Bay, which had produced about 10,000 barrels of cement in 1919, failed. The failure was probably due to the overlooking of some vital factors in the manufacture of this article. A much more favorable locality than Binangonan has been located by a geologist of the division of mines, Bureau of Science, at Naga, Cebu, and a contract has, within the past few months, been let by the National Development Company to the National Cement Company, of which Mr. C. F. Massey is the general manager. Mr. Massey purchased the machinery for the plant. It appears that all the material factors necessary for the operation of this company are favorable. The success of the undertaking now depends upon the management, as the Government has been very liberal in its support. It will probably be a full year before this concern will be under way. There are other localities where raw cement materials are available; Batan Island is in many ways very favorably situated; but, considering market, labor, coal, and transportation, Cebu appears to be somewhat better favored than the former.

MINERAL WATERS

There are many kinds of mineral water in the Philippines. The Bureau of Science has recently published a bulletin which very completely deals with this subject. In spite of the existence of many fine natural waters, the largest production from any one source is that at Los Baños in Laguna Province, where an artificially charged water is bottled and sold under the name of "Isuan."

According to Heise and Behrman, of the Bureau of Science, Philippine mineral waters come under the following heads: Thermal; carbonated; ferruginous; muriated; sulphated; bromide; sulphurated; and arsenical.

About 100,000 pesos' worth of bottled water are imported into the Philippines every year, all of which might be replaced by domestic waters of equal quality.

In the discussion of mineral waters, we must not overlook the hundreds of excellent deeper wells that have been drilled in the last few years in all parts of the Archipelago. Water from deep sources has been a large factor in the greatly improved health conditions among the Filipinos, and a very appreciable betterment in the physique of the people, as a result of good water together with good food, is to be noted. It is difficult to place a money value upon this water.

BITUMINOUS ROCK

The Leyte Asphalt and Mineral Oil Company, Limited, reports that the 1920 production of bituminous limestone was approximately 2,000 tons, valued at about 30,000 pesos. Of this amount, 1,350 tons were shipped to the Philippine Government at Manila and Cebu, while about 20 tons were sent as samples to Australia and Japan. The past year saw considerable exploration and improvement work on the properties near Baliti, Leyte. The company has under construction a new pier and has completed two new gravity inclines, as well as some new roads between the Lucio mine and the new wharf. The increase in production from 600 tons in 1919 is encouraging.

ROCK, SAND, AND GRAVEL

Many people overlook such plebeian items as these three—rock, sand, and gravel—because they are found nearly everywhere, and it is not usual to think of values in such common articles. However, the production of these items in 1920 amounted to one and one-fourth million pesos. It is interesting to note in this connection that one of the contractors doing the largest business in this material in the city of Manila is a Tagalog woman. This fact, coupled with two equally interesting ones, namely that the largest producer of pig iron in the Philippines is also a Tagalog woman, from Angat, and that there is still another woman who is developing a coal mine in Albay Province, indicates that the Filipino women are not behind in the development of our natural resources.

In other places and at other times I have called attention to other mineral deposits not yet exploited and, therefore, we may pass by them now.

PETROLEUM

There is one other mineral product, petroleum, which gives some promise of becoming an asset; but whether or not it does so will depend upon the results of drilling operations now in progress on Bondoc Peninsula, Tayabas Province, Luzon. Here the Richmond Petroleum Company, a subsidiary of the Standard Oil Company of California, is drilling on the most favorable-looking structure I have yet seen in the Archipelago. If its borings are successful on this structure, there are many other localities which it would be justifiable to prospect by boring. If it is not successful after three or four holes are put down, further boring in this part of the Philippines would be considered a doubtful venture. There are a number of seeps known in the Islands, and the oil is of a high grade. It is now only a question of quantity.

FACTORS AFFECTING MINERAL DEVELOPMENT IN THE PHILIPPINE ISLANDS

The following factors seem to be the most important in their effect upon the development of the mining industry in this Archipelago:

Political instability.
General world conditions.
Laws and regulations.
Taxes.
Capital.
Costs.
Transportation.
Geological conditions.
Labor.
Personnel.
Hygiene.

Each of these eleven items will be briefly discussed.

As mining is perhaps the most sensitive of all the industries, it is the first to respond to a change in economic conditions. The risks inherent in the business are sufficiently great to make those who follow it as a business doubly cautious; and so, when additional risks such as those attendant upon political instability, unreasonable taxes, etc., are to be faced, these risks are often enough to deter those who look upon mining as a business and not as a gamble. Therefore, it can be confidently said that one of the greatest drawbacks to the upbuilding of this industry is the indefinite political status of the country. Business men want, and have a right, to know what sort of government they will have to deal with, and it does no good to try to argue with them on this point. Political stability, then, is the first essential for the mining industry.

GENERAL WORLD CONDITIONS

We need not spend much time discussing this already hackneyed subject. Suffice it to say that the Philippines were not overlooked, either by the mushroom prosperity or by the subsequent deflation growing out of the war. It is my opinion that in some lines at least the industry will go forward, though perhaps slowly, now that many men have been thrown out of work and the need for gold is becoming acute. The decrease in prices will also have its beneficial effect since the purchasing power of gold has consequently risen.

We may look, therefore, for an increase in activity in both the gold and the coal branches of the industry; but in copper, iron, manganese, etc., the Philippines will not show much activity for some time to come.

LAWS AND REGULATIONS

At the present time our mining laws are in a state of flux; there are two schools of thought, both sincere, and both having arguments to support their respective contentions. The conflict is between those with strong individualistic tendencies and those with a more social (I purposely avoid the word "socialistic") outlook on life.

The old Act of Congress of 1902, which is a modification of and a decided improvement on the United States law, its parent and model, still holds for the metals; but in the case of coal and petroleum the leasing system has been adopted by the Philippine Government.

In addition to lack of uniformity in the laws controlling the development of the different classes of deposits, which a complete revision would remedy, there are some absurd provisions in the present laws which should be cleared away, particularly as they are constantly being evaded. One of these is the altogether unreasonable provision that a person or corporation can take up only one claim on a lode (Sec. 33); and the second, that a person interested in one mining corporation cannot become interested in any other (Sec. 75). The practical effect of the last would be to prevent any person successful in one venture from bringing his experience and special talents to bear upon other projects in this difficult field. It amounts to penalizing efficiency.

As both of these unreasonable restrictions were commented upon by Mr. McCaskey, the second chief of the Mining Bureau, as long ago as 1905, all the very strong arguments which can be made against them need not be repeated. Our proposed new mining law, will do away with both of these sections.

TAXES

The whole question of mine taxation is a mooted one in many countries. The chief trouble arises from the fact that persons unacquainted with the industry control the levying of taxes. The second source of trouble comes from the desire of most governments to make as much as possible out of the industry, either by taxes or by royalties, and they often "kill the goose that lays the golden egg."

The following three rules ought to be strictly adhered to in this matter of taxation of the mining industry:

1. Try to help, not hinder, the industry.
2. Tax production only.
3. Keep as nearly as possible to the single-tax plan.

At the present time the coal industry is, according to information supplied us by an engineer engaged in the business, taxed as follows:

Gross income	per cent	1.50
Rental:		
First year	pesos per hectare	2.50
Second year	do	5.00
Royalty	pesos per ton	0.10
Vendor's tax	do	0.25
Timber	pesos per cu. m.	0.25–1.25

Needless to say, this not only is a nuisance but is unfair, and the Government loses indirectly if not directly thereby.

CAPITAL

This again is an old, time-honored, and threadbare subject. Of all forms of industry the mining business, except for certain kinds of crude gold washing, requires capital, and usually lots of it.

In the Philippines our mining business has had to depend upon small amounts of locally raised money, supplied chiefly by Americans with the speculative instinct, or it has come from New Zealand, Australia, and the China Coast. The Filipinos have been very reluctant to risk their money and consequently they have had little share in whatever benefits have so far accrued. American capital from the homeland has, with good reason, been very chary about going so far afield. It is needless to say that the new policies being put into effect at Washington will ameliorate this condition of things and we ought to see, with the determination of a fixed status for the Islands, a greater movement of American capital in this direction.

COSTS

Costs of supplies, freight charges, skilled superintendence, depreciation, and maintenance are all excessive in this part of the world, as the following few examples will indicate:

1. It costs as much to ship a ton of freight from Manila to Zamboanga, as from Japan to Manila.
2. Most of the interisland boats are not able to handle heavy machinery.
3. Lighterage charges at places without loading facilities are often as high as 18 to 20 pesos per ton.
4. Skilled employees, in some lines, brought from the United States are working on a 25 per cent bonus, plus subsistence (all on a gold basis); this means practically a surcharge of 50 to 75 per cent.

TRANSPORTATION

In spite of the great strides that have been made in the Philippines within the past dozen years in the matter of transportation facilities, it remains a fact that many parts of the Archipelago are without adequate means of communication. This has been brought definitely to my attention lately during visits to the central part of Mindanao in connection with an oil reconnaissance, and into the Cordillera Central of Luzon inspecting gold prospects. While there are good horse trails in those regions, there is no road suitable for the transportation of heavy machinery. Such islands as Mindoro, Palawan, and Polillo, with practically no roads, are notorious for their lack of transportation facilities.

Of course, adequate transportation will be forthcoming whenever the proper inducements for the development of the mining industry are put forth. In a later paragraph some definite recommendations along this line are made.

GEOLOGICAL CONDITIONS

In booster literature the number and value of Philippine mineral deposits have generally been exaggerated. Although mineral deposits of one kind or another have been found in all parts of the Archipelago and it may be said that mineralization is widespread, I am compelled, after ten years' intimate acquaintance with the country, to say that very few already discovered deposits are of sufficient extent or richness to attract capital for the launching of large-scale operations. The comparative geologic youth of most of the formations, the lack of persistence due to faulting and pinching, the prevalence of archipelagic instead of continental conditions—all these have had their effect upon the location, the size, the continuity, and the values of the various metalliferous and nonmetalliferous deposits. As illustrations one need merely point to the small rich placers of the Paracale district of Camarines Norte, now practically exhausted; the lenticular manganese deposits of the Aroroy district, Masbate; or the faulted, twisted, and pinched coal seams of western Batan. Even the apparently large Mancayan copper ore deposit of north-central Luzon, on thorough examination, is seen to be of a low grade, with some local enrichments to be sure, faulted, and of doubtful commercial value.

In the entire Benguet district there is to-day only one mine that has turned out to be a paying venture. By this I do not mean to say that many good and even large deposits may not exist. The country is potentially rich in minerals, but prospecting and exploitation have left much to be done.

With such conditions, it behooves us to endeavor to make all the other circumstances affecting the industry's welfare as favorable as possible; that is to say, the inherent risk and difficulties are great enough without human-made ones being added. The fact that the geological features are not appreciated by the average government official is the chief reason for the lack of liberal laws and regulations in the past. This applies to other countries as well as to the Philippines.

LABOR

In discussing labor I am, of course, touching upon one of the most vital factors in this or any other industry and am also, in doing so, laying myself open to criticism, inasmuch as many phases of the subject can be matter of personal opinion only.

Some years ago no less an authority than Herbert Hoover (perhaps the most competent in the mining world to-day) made a comparison of mining labor in many parts of the world, based largely upon personal employment of the different nationalities and classes. While his exact conclusions are not at hand just at the moment, the conclusion was that Caucasian labor, because of greater experience and adaptability to this kind of work, though costing more per man, was the cheapest per unit; and that native labor, in many of the outlying places in which he had operated, though cheap per man, was very expensive per unit of output. Naturally this general conclusion would be modified according to the nature of the work.

In the Philippines we find that in some instances native labor, after a little training and under the right kind of foremen, has excelled the Caucasian; but such a condition is exceptional. The Filipino laborer is neither so good as the booster would claim nor so poor as some of his detractors try to make out. In general intelligence he has the advantage over many kinds of native labor in other lands. He is often lacking, however, in physical stamina, experience, and persistence, and he is the victim of a lot of "costumbres" which are very annoying to his employer. All this, coupled with a lack of initiative, makes him a not altogether satisfactory type of laborer for mining.

Another fact should be pointed out, in fairness to the Filipino: he is working in a most trying climate, in which a white man scarcely does any manual labor at all. Furthermore, the several tribes differ in the quality of the labor. Without wishing to make any invidious comparisons in the rating of Filipino labor, as far as mining work is concerned I would place the Ilocano at the top of the list. One thing greatly in the Filipino's favor is his tractability.

The average wage for the unskilled mine laborer in the Philippines is from 1 to 1.60 pesos. It costs, on the average, 30 centavos per day to feed him.

PERSONNEL

The personnel of the skilled force or of the superintendence is something of vital importance in a country like this. The success of many a venture is either assured or marred according to the personality and tact of the managers, superintendents, and foremen. Only men of adaptability, pleasing personality, tact, and forbearance ought to be sent to these Islands to take charge of important mining operations. As soon as the climate begins to tell in manifestations of irritability, the persons exhibiting them should be shipped home and replaced by fresh men. It should be needless to say also that young men of steady habits should be preferred. Persons with strong racial prejudices should, of course, be kept at home.

HYGIENE

In spite of all that has been written about health and climate in this country, many people will not learn from experience, and they find themselves and their undertakings sadly handicapped through neglect or oversight of some of these matters.

The only proper procedure for new companies is to get complete instructions from the Bureau of Science and the Bureau of Health before beginning permanent operations. Furthermore, the men selected to come over from the United States should all be carefully examined as to general health.

There are many recommendations regarding living habits which might be laid down, but we shall not go into details now. One point we must emphasize here, not on any moral ground, but as a purely economic measure; the type of imbiber of alcoholics known as the "booze hister" has no place in Philippine mining. He should be shipped out of the country as soon as possible.

RECOMMENDATIONS

The chief recommendations that I desire to make come under the following nine heads:

1. *Administration.*—During the year, the Secretary of the Department has consulted our division with reference to the creation of a Bureau of Mines. Mr. Faustino made certain specific recommendations after consultation with me. I am not in entire agreement with the plan for a separate Bureau of Mines, though there seem to be some good administrative reasons for favoring such a plan, and I respectfully submit the following suggestions, all of which are closely connected and can best be represented by a diagram (see fig. 1).

It will be seen that the center of this diagram is occupied by a "Bureau of Forests and Mines," the principal functions of which would be administration and inspection. The present Bureau of Forestry, which is well organized and well administered and whose work now has a great deal to do with mining claims, could easily take over the present functions of the mineral

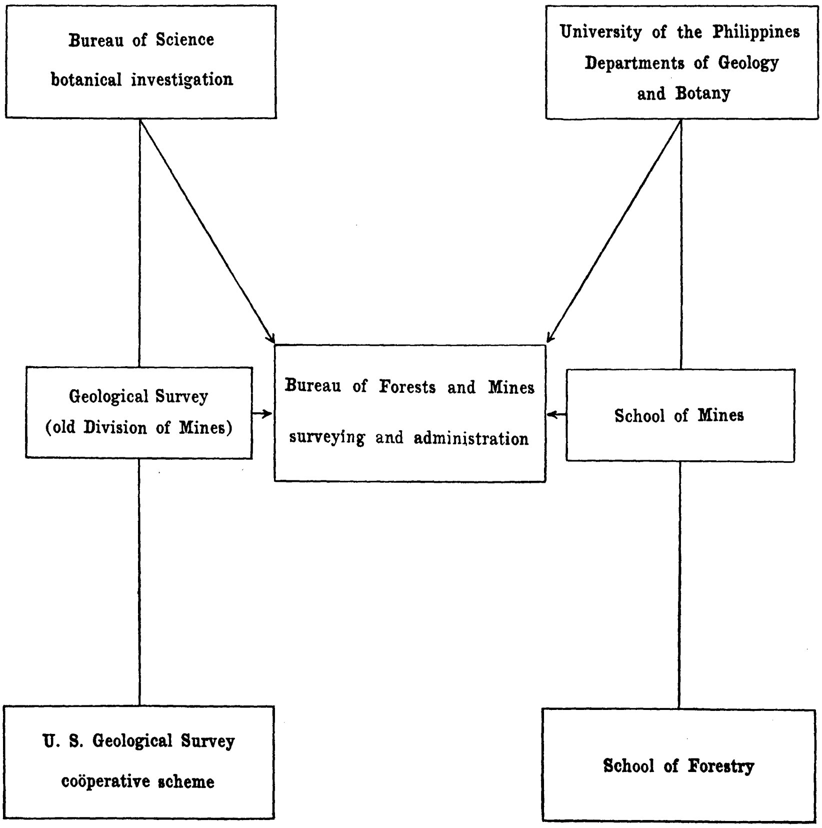

FIG. 1. Suggested scheme for coördination of related Government entities.

surveying division of the Bureau of Lands. The present division of mines of the Bureau of Science could then be changed into a sort of Geologic Survey which would continue the present chief work of that division. This work should never be divorced from the Bureau of Science as long as that institution exists. It is of a scientific character and should be under the supervision of the director of that bureau, where it can be coördinated with other closely related scientific work of that institution. The activities of this survey would be greatly augmented by coöperation with the Geological Survey of the United States whereby specialists from that survey would be detailed, for limited periods and for special problems, to the Philippine field. On the other side of the diagram we have the University of the Philippines, with its departments of geology and botany and school of forestry. To these might be added a school of mines and all four coördinated with this proposed Bureau of Forests and Mines and also with the Bureau of Science.

It would seem that the time had now arrived for the establishment of some sort of mining or pre-mining engineering courses in connection with the University of the Philippines, as we need some means of training young men for the proposed Geologic Survey and for the Bureau of Forests and Mines, or Bureau of Mines, as the case may be, and also for the more general dissemination of specific knowledge among Filipinos with reference to mining methods. At the present time the general mass of Filipinos is almost hopelessly ignorant of minerals and mining; the people must learn something about these things or they are doomed to great disappointment in some of their other aspirations. I have tried to emphasize this on several occasions, both in writing and in speech, to Filipinos. This is, in my opinion, a serious matter, which many of them do not seem to realize. For an example of what can be done along this line, attention is called to the so-called geological school for young Chinese in Peking. China now has a Geologic Survey entirely manned by Chinamen, retaining only American and Swedish expert advisors.

2. *Land registration and surveys.*—It has been apparent for some time to those who are interested in a quick and easy registration of land and the surveying of the same that some system of coördinates is necessary to which to tie the surveys of various parcels of land. In the western part of the United States, as is well known, we have the range and township plan, a township consisting of 36 square miles and 36 sections, each section a square mile in area. These are laid out according to meridians and parallels of latitude, and all surveys of public and private land are tied to these coördinates. I would suggest that in the Philippines we call these "quadrangles" instead of "townships" and that they be 10 or 100 kilometers on a side, thus giving sections of 1 square kilometer and then by a simple formula we can denote any particular quadrangle in the Philippine Archipelago; as, for example, 125 Y 15 X, the "Y"s indicating the latitude and the "X"s the longitude. These quadrangles can be surveyed off very rapidly by use of light reconnaissance transits and stadia. Much of the surveying now done in the Philippines is by chaining,

which is altogether unnecessary, costly and slow. Bondoc Peninsula, if oil is found there in any commercial quantities, will have to be divided into some such system of coördinates; otherwise there will be endless and hopeless confusion. When the public domain has been divided in this fashion, we can carry on our geologic and topographic surveys by coördinates, and the work will be much more orderly and will be greatly expedited.

3. *Government-owned mines.*—I cannot forego a brief discussion of a very important matter with which I have had some very particular connection during the past year; namely, the various national mining projects. My investigation of the National Coal Company has led me seriously to question if national mining projects, whether controlled by Filipinos, Americans, or any other people, are wise. The reasons for the difficulties of this concern are many, not all of which should be laid at the door of the Philippine Government or of the Filipinos. Inexperienced Americans on the board of directors are equally responsible, but the gravest objection of all to these national projects is that they are apt to become hopelessly mixed with politics. A much safer plan, and one that would doubtless bring quicker results, would be to subsidize worthy private companies, the Government exacting some security for the money so lent. If the Government received no more than the interest on the loan, it would be amply repaid. Indeed, this is practically the plan adopted in the case of the National Cement Company. If that Company does not succeed, it will not be due to any lack of support from the Government.

In another part of this report we have outlined how a successful iron industry might be developed.

The National Development Company with which, strange as it may seem considering his position in the Government, the chief of the Division of Mines has no direct connection (nor has he first-hand knowledge of it), is somewhat different. There seems to be a place for a National Development Company; but, if the National Development Company is going to foster mine projects, it should at least have one man on its board of directors who is an experienced mining man.

4. *Roads.*—More and better roads are badly needed in and adjacent to the various mining districts.

a. A wagon road should be made of the present north and south trail through the Mountain Province, so that one could travel from Manila to Aparri on four wheels. From this main road there should be laterals wherever they are justified. One in particular comes to mind at this time: a wagon road to the barrio of Acupan in the Baguio district. This would aid in the development of three or four promising mining projects. Toward the cost of such road building the Government might contribute one-third, the province one-third, and private interests one-third.

b. There should be a road from Aroroy southward across Masbate Island, This would help several mining projects to become producing mines.

c. There should be a wagon road from Fort Pikit, in Cotabato Province, north through Banisilan into Bukidnon.

d. There should be a second- or third-class road along the east coast of Luzon.

These roads would serve other interests as well as the mining interests.

5. *Power*.—Such projects as the Agno River Power Plant now being planned by the Government should be pushed to conclusion; or, if the Government finds it impossible to carry out its plans, private concerns should be allowed to do the work under governmental control. The Baguio mineral district could turn out ten or twenty million pesos instead of about a million. In fact, it is not unreasonable to expect that the mineral belt from Baguio north beyond Bontoc, if developed, would support the entire Government of the Mountain Province and vastly enrich that country.

6. *Support for the Division of Mines*.—I hesitate to harp again upon the old matter of adequate support for the Division of Mines. At the risk of becoming a nuisance, I am going to make the suggestion that the money from the rentals on coal and petroleum leases, and such other mineral-land leases as may be provided for in the future, be turned into a fund to be used for topographic and geologic surveys.

7. *Mining Law*.—I have already alluded to the preparation of a draft of a new mining law. This is the work of three men in particular, with the assistance and advice of many of those actively engaged in mining in the Philippines. Special mention should be made of Judge F. B. Ingersoll; the Lawrence brothers of Ross and Lawrence, attorneys; Mr. A. W. Beam, president, Benguet Consolidated Mining Company; and Dr. Roy E. Dickerson, geologist and representative of the Richmond Petroleum Company. It should be understood clearly at the outset that this is a compromise measure, as a result of an attempt to harmonize a multitude of conflicting opinions, the chief bone of contention

being the well-known, and by some regarded as infamous, regalian doctrine. I shall not go into an elaborate discussion of this here, further than to reiterate that I am in general agreement with the Filipino members of the committee which drafted this bill on the general regalian principle. On the other hand, I am opposed to any idea of confiscation, or of making this principle retroactive with reference to lands already alienated under patent or Torrens title. The general doctrine that the mineral resources are an asset of all the people and that they are not for the exclusive use of a few privileged persons is so thoroughly in accord with the modern trend of opinion as to social relationships that there seems to be no sound argument against it. Of course, the chief difficulty arises from the fact that the Congress of the United States in the Act of July 1, 1902, did not make its stand on this subject perfectly clear, though the presumption is that that body meant to abrogate the regalian principle. Although the Philippine Supreme Court, a majority of whose members were Filipinos, rendered an opinion in favor of it, the final settlement, in the writer's judgment, will rest with the Supreme Court of the United States.

8. *Geological Surveys.*—Several districts merit and almost demand attention from the Government in the way of geological surveys; these are:

a. The central part of Mindanao, for petroleum; detailed mapping.

b. Geologic reconnaissance of Negros.

c. Geologic reconnaissance of Palawan.

d. Detailed survey of the Mountain Province mineral belt, from Baguio north to Bontoc, and a reconnaissance from there to the north coast.

e. Reconnaissance of the Sierra Madre Mountains of northeastern Luzon.

9. *Miscellaneous suggestions.*—Other minor suggestions have occurred to me as possibly worthy of some consideration; these are: Granting bonuses for discovery of new deposits of economic importance; establishing an advisory mining council from among the members of the mining fraternity; holding classes for prospectors,[1] etc.

In conclusion I have some hesitation in predicting a healthy growth of the mining industry unless some unfortunate tendencies that have come about in the last six or seven years are

[1] The last two have been put into effect since this paper was written.

radically changed. There is no question about the potential mineral wealth of the Philippine Islands. All those qualified to pass judgment are convinced that there are deposits here of merit, even though not all are extensive. Americans and other foreigners have attempted to do what they could to develop these resources. Their efforts have not always been encouraged. There is a very definite responsibility in this direction which many Filipinos for one reason or another have evaded. It must be realized sooner or later that the business of mining is carried on successfully by only a few nations and that an agricultural people like the Filipinos cannot hope to master alone the complicated technology of this, the most difficult and exacting of all industries.

STATISTICS OF MINERAL PRODUCTION IN THE PHILIPPINE ISLANDS

By HUBERT G. SCHENCK

From 1907 to 1920, inclusive, the Philippine Islands have produced nearly sixty million pesos' (thirty million dollars') worth of various minerals.[1] This is not an extraordinarily large figure, but it is sufficient to prove that the mineral industry here is well established. There have been, of course, numerous setbacks and, at times, phenomenal increases. The diagrams (figs. 2 to 4) will show this at a glance. An examination of Table 1 will enable one to see that the mineral industry has grown steadily from a total production in 1907 of 234,079 pesos to 7,610,769 pesos in 1920; that is to say, more than thirty-two times the production fourteen years ago.

Mr. Leopoldo Faustino, former acting chief of the Division of Mines, compiled the figures for 1919, while the writer is responsible for those for 1920, as well as for the table of comparative productions and the graphic representations of the same. All estimates and totals are supported by letters from various companies, producers, miners, provincial officials, and the Bureau of Commerce and Industry. The totals, in some cases, may be incomplete, but the writer thinks that it is better to err in giving an underestimate rather than in endeavoring to make it appear that the Philippines have a larger mineral industry than is actually the case. It might be mentioned at this time that the difficulties of compilation would be enormously lessened if producers would render their reports more promptly and without repeated urging.

[1] The figures for the Mineral Production for the state of California, U. S. A., for the year 1920 have just been received. They are 242,099,667 dollars, over half of which is due to petroleum production.

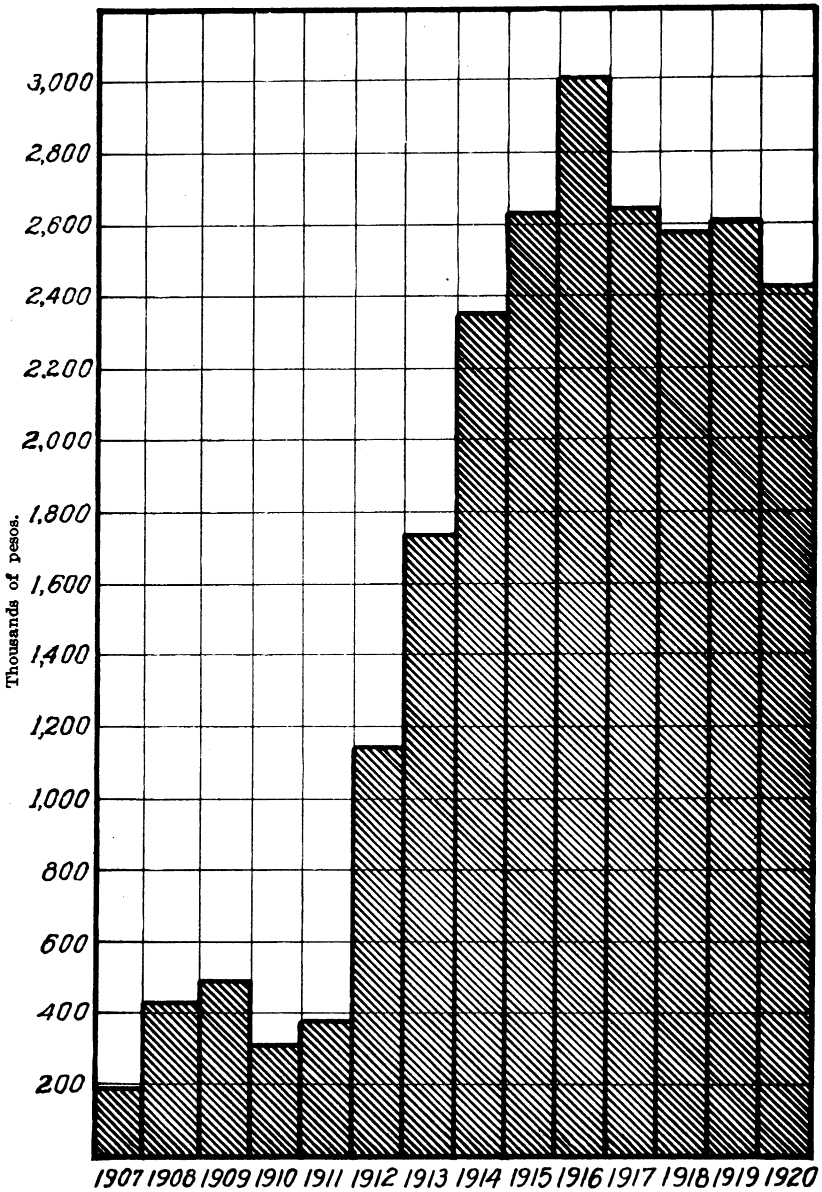

FIG. 2. Production of gold.

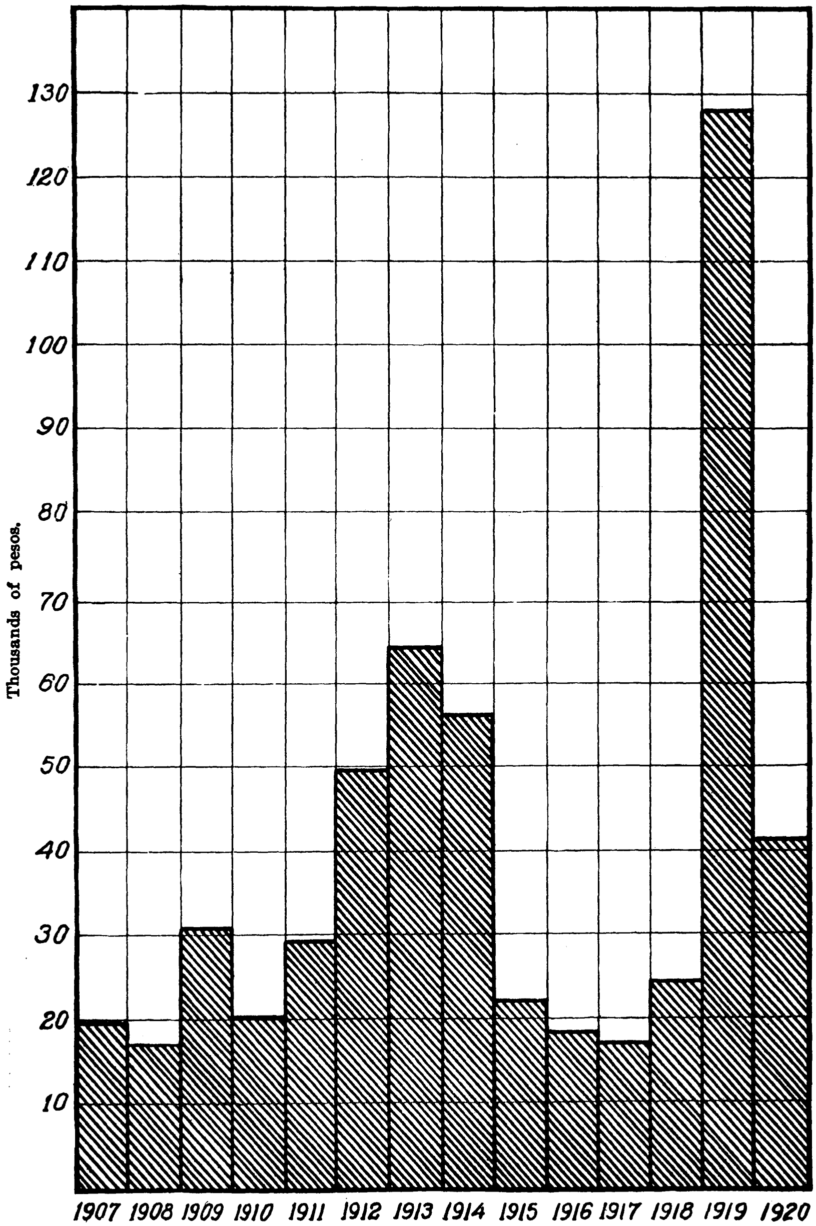

FIG. 3. Production of iron.

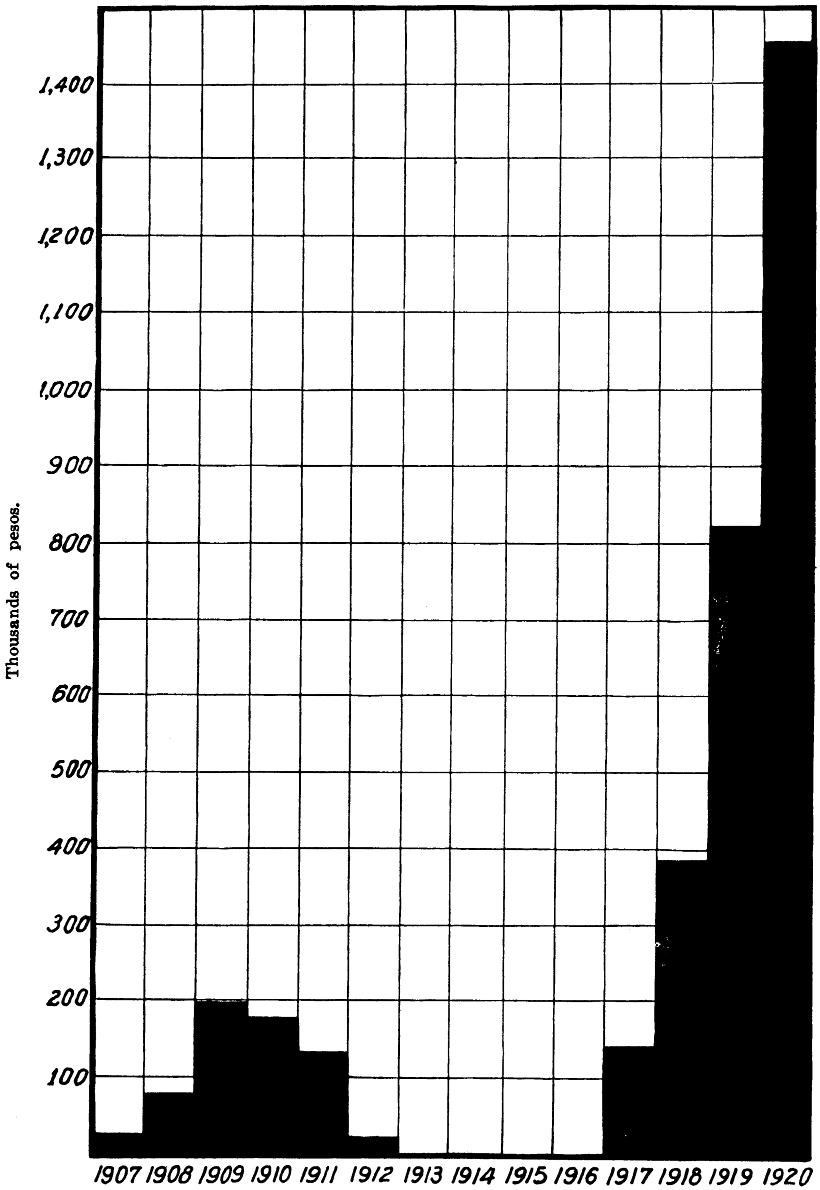

FIG. 4. Production of coal.

TABLE 1.—*Mineral products of the Philippine Islands for the calendar years 1919 and 1920.*

Product.	1919 Quantity.	1919 Value.	1920 Quantity.	1920 Value.
		Pesos.[a]		*Pesos.*[a]
Metallic:				
Iron ....metric tons..	67	34,964	87	40,191
Iron ore........do.....	18,598	92,990	(b)	(b)
Silver[c] ....fine grams..	261,558	18,828	307,343	19,261
Gold........do.....	1,970,651	2,619,449	1,920,753	2,424,606
Total value of metallic	....	2,766,231	....	2,484,058
Nonmetallic:				
Asbestos........metric tons..	375	37,500	(b)	(b)
Bituminous rock........do.....	1,400	21,000	2,000	30,005
Cement ....barrels..	10,396	124,752	(b)	(b)
Clay products[d]	....	700,000	....	570,880
Coal........metric tons..	82,892	822,300	58,888	[e]1,452,200
Lime ....do.....	20,000	534,000	3,001	[f]10,872
Mineral waters ....liters..	225,000	60,000	479,817	[g]121,
Sand, gravel, crushed rock..cubic meters..	403,986	588,379	627,774	1,228,332
Stone, building........do.....	404,709	832,630	49,373	311,861
Salt........metric tons..	32,000	900,000	62,383	1,401,307
Sulphur ....do.....	12	1,680	(b)	(b)
Total value of nonmetallic........	....	4,622,241	....	5,126,711
Grand total........	....	7,388,472	....	7,610,769

[a] One peso Philippine currency equals 100 centavos, normally equals 50 cents United States currency.
[b] No production as such.
[c] No silver is mined separately, but a small amount is alloyed with the gold.
[d] Includes pottery, brick, and tile. Incomplete figures.
[e] This is an average of abnormal postwar prices.
[f] Data incomplete.
[g] Estimate based upon incomplete data.

DIRECTORY OF PHILIPPINE MINES

By Hubert G. Schenck

The directory of mine owners, mine lessees, dredging companies, and coal operators in the Archipelago published in The Mineral Resources of the Philippine Islands for the Years 1917 and 1918 has been revised so as to bring it up to date. That it is practically impossible to list each small "paquiao" mine operator can be readily understood.

During 1919 and 1920 several gold mines and dredges ceased to operate, but new developments are taking place. The reader will note, in this regard, that gold mining is becoming more and more concentrated in the Baguio Mineral District; nine of the nineteen gold mines listed herein are situated in the Mountain Province, while in 1917–1918 only eight of the twenty-two were so located.

The majority of the coal operators listed hold revocable permits, which are limited to 4 hectares each. The Bureau of Science has a number of permits recently granted, but these have not been included in the directory, because no data of production are in hand.

It is realized that this list is not as complete as it might be, and for this reason it is requested that all interested in the mineral industry in the Philippines send to the Bureau of Science the names and addresses of operators who may have been omitted. Only by hearty coöperation on the part of all those engaged in mining can a complete directory of this nature be compiled.

The Division of Mines desires to acknowledge its indebtedness to all those who assisted in the preparation of this directory. If any miner or company did not receive a request for information, it is hoped that his name or the name of his company will be submitted to the division, in order that the mailing list may be complete.

Directory of mine operators in the Philippine Islands (August, 1921).

GOLD.

Name.	Post-office address.	Location of mine or property.	Activity.
Acupan Mining and Milling Co	c/o Wm. M. Haube, 827 R. Hidalgo, Manila	Batwaan Creek, Benguet, Luzon	Developing.
Antamok Valley Mining Association	c/o Wolfson and Wolfson, 65 Plaza Cervantes, Manila.	Antamok Valley, Benguet, Luzon	Do.
Argus Mining Co	Napuangan, Aroroy, Masbate	Napuangan, Aroroy, Masbate	Do.
Benguet Consolidated Mining Co	Kneedler Building, Manila	Antamok, Benguet, Luzon	Milling.
Colorado Mining Co	Uy Chaco Building, Manila	Aroroy, Masbate	Do.
Demonstration, Ltd	c/o H. P. Whitmarsh, Baguio, Mountain Province.	Tuba, Benguet, Luzon	Developing.
Gillies, John S	Suyoc, Mancayan, Mountain Province	Suyoc, Lepanto, Luzon	Small-scale operations.
Headwaters Mining Co	Baguio, Mountain Province	Antamok River, Benguet, Luzon	Developing.
Itogon Group	c/o I. B. Dexter, Manila	Itogon, Benguet, Luzon	Do.
Keystone Mining Co	c/o G. M. Willy, Aroroy, Masbate	Aroroy, Masbate	Do.
Kuruon Mining Co	Zamboanga, Mindanao	Zamboanga, Mindanao	Do.
Magma Group	c/o H. P. Whitmarsh, Baguio, Mountain Province.	Itogon, Dunglan Creek, Benguet, Luzon	Do.
Mentzer, George	Binalonan, Pangasinan	Lubang, Mountain Province	Milling.
Moisan and Müller	Maliit, Mambulao, Ambos Camarines	Maliit, Mambulao, Ambos Camarines, Luzon	Do.
Lianga Mines, Ltd	Lianga, Mindanao	Lianga, Mindanao	Installing dredge.
Philippine Dredges, Ltd	Paracale, Ambos Camarines	Paracale River, Ambos Camarines, Luzon	1 dredge operating.
Schwab, Paul	Aroroy, Masbate	Aroroy, Masbate	Intermittent operations.
Syndicate Mining Co	101 Lara, Manila	do	Milling.
Tiago Group	Aroroy, Masbate	Cabuyudu River, Aroroy, Masbate	Developing.
Inca Group	Baguio, Mountain Province, c/o Wm. Ebert	Antamok River, Benguet, Luzon	Do.

Directory of mine operators in the Philippine Islands (August, 1921)—Continued.

Name.	Post-office address.	Location of mine or property.	Activity.
IRON.			
Concha, Francisco de la	Sibul Springs, Bulacan	Sapang-bacal, San Miguel, Bulacan	Operating.
Concha, Joaquin de la	Cabanatuan, Nueva Ecija	Camaching, San Miguel, Bulacan	Do.
Cruz, Anacleto	Angat, Bulacan	Muntamurong, Angat, Bulacan	Do.
Fernando, Juana A	do	Maon and Macabaroc, Angat, Bulacan	Do.
Fernando, Maria A	do	Sapang-bacal, Angat, Bulacan	Do.
Fernando, Matias A	do	Angat, Bulacan	Do.
Fernando, Valentin A	do	do	Do.
Manila Iron and Steel Co	c/o O. P. Rhudie, Manila	Mariveles, Bataan	No production.
Sarmiento, Marto	Angat, Bulacan	Sapang Caliñgog, Angat, Bulacan	Operating.
Sarmiento, Vicente	do	Sampaloc, Angat, Bulacan	Do.
Vamenta-Chaves Mining Co	Cagayan, Misamis	Bukidnon, Mindanao	No production.
COPPER.			
Mancayan Copper Mines	Mancayan, Lepanto, Mountain Province	Mancayan, Mountain Province	Developing.
LEAD, ZINC, AND COPPER.			
Marinduque Mining Co	c/o E. E. Elser, Kneedler Building, Manila	Marinduque Island	Idle.
Schwab, Paul	Aroroy, Masbate	Masbate Island	Developing.
ASBESTOS.			
Ilocos Asbestos Products Co	Manila	Dungon-Dungon, Bangui, Ilocos Norte	Idle.

ASPHALT AND BITUMINOUS LIMESTONE.

Leyte Asphalt and Mineral Oil Co., Ltd	Villaba, Leyte	Villaba, San Isidro and Leyte, Leyte	Operating.

COAL (PRODUCERS ONLY).

Abella, Apolinar	Cebu, Cebu	Lotloton, Toledo, Cebu	Revocable permit.
Adlawan, Monico	Talisay, Cebu	Pooa, Toledo, Cebu	Do.
Alecaba, Pablo	Toledo, Cebu	Near Toledo, Cebu	Do.
Alferes, Placido	do	Masaba, Cantabaco, Toledo, Cebu	Do.
Ariate, Juan	do	Near Toledo, Cebu	Do.
Bajarias, Fausta	Dalaguete, Cebu	Mantalongon, Dalaguete, Cebu	Do.
Barker, F. E	Legaspi, Albay	Carcaran, Batan	Do.
Bellesa, Luis G	Naga, Cebu	Naga, Cebu (?)	Do.
Buntayan, Gregorio	Cebu, Cebu	Near Toledo, Cebu	Do.
Canonigo, Vicente	Naga, Cebu	Naga, Cebu (?)	Lease.
Cepado, Restituto	Minglanilla, Cebu	Minglanilla, Cebu	Revocable permit.
Codilla, Aquilina	128 Colon, Cebu, Cebu	Near Toledo, Cebu	Do.
Cumings, Edgar G	Toledo, Cebu	Cambanog, Toledo, Cebu	Limited license.
Danao Coal Mining Syndicate, Ltd	Danao, Cebu	Danao, Cebu	Private.
Enriquez, Eugenio	1 Manila St., Cebu, Cebu	Guinkiyutan, Toledo, Cebu	Revocable permit.
Ford Lease	c/o C. D. Johnston, Cebu, Cebu	Naga, Cebu	Lease.
Iriarte, Prudencio	100 Juan Luna, Cebu, Cebu	Cantabaco, Toledo, Cebu	Revocable permit.
Jara, Arcadio	Capilihan, Cebu	Capilihan, Cebu	Do.
Jola, Arcadio	Talisay, Cebu	Talisay, Cebu	Do.
Juarez, Antonia	do	Cabungahan, Cebu	Do.
Lebomfacil, Lorenzo	Toledo, Cebu	Masaba, Cantabaco, Toledo, Cebu	Do.
Libre, Teofilo	Cebu, Cebu	Near Toledo, Cebu	Do.
Natad, Ambrosio	do	do	Do.
National Coal Company:			
Cebu	do	Mount Licos, Cebu	Government.
Mindanao	Malangas, Mindanao	(1) Gotas, (2) Butong, (3) Camp Wilmot, Mindanao.	Do.
Philippine Coal Mining Co	Box 752, Manila	Batan, Batan Island	Lease.

Directory of mine operators in the Philippine Islands (August, 1921)—Continued.

COAL (PRODUCERS ONLY)—Continued.

Name.	Post-office address.	Location of mine or property.	Activity.
Rivera, Benito and Rivera, Teofilo	Naga, Cebu	Cantabaco, Naga, Cebu	Revocable permit.
Saysen, Isidro	do	Naga, Cebu	Do.
Toledo Coal Mines, Ltd	Box 494, Manila	Taop, Toledo, Cebu	Lease.
Uling Coal Mines, Ltd	Cebu, Cebu	Uling, Naga, Cebu	Private.
Veloso, Moises	Naga, Cebu	Naga, Cebu	Revocable permit.
Villaver, Alberto	Tubod, Minglanilla, Cebu	Biga, Toledo, Cebu	Do.
Yriarte, Angel and Yriarte, Prudencio	100 Juan Luna, Cebu, Cebu	Near Toledo, Cebu	Do.
MARBLE (ORNAMENTAL).			
Bagondol, Pedro	Romblon, Romblon	Romblon, Romblon	
Magdato, Sancho	do	Soypo, Romblon, Romblon	Operating.
Magdato, Vicente	do	do	
Martinez, Manuel	do	do	Operating.
Mazo, Lope	do	do	Do.
Mindo, Ambrosio	do	do	Do.
Montojo, Rafael	do	Cajimos, Romblon, Romblon	Do.
Moral, Julio	do	Soypo, Romblon, Romblon	Do.
Mula, Roman	do	Romblon, Romblon	Do.
MINERAL WATERS.			
Isuan, Inc	Manila	Los Baños, Laguna	Operating.
Corporacion Marilao	Marilao, Bulacan	Marilao, Bulacan, P. I	Do.

PETROLEUM APPLICANTS.

American Oil Co		Tayabas Province	Lease.
Columbia Oil Co		do	Do.
Heise, E. A	Manila	do	Do.
Lucena Oil Co	Lucena, Tayabas	do	Do.
McDaniel, E. W	Manila	do	Prospecting.
Manila Oil and Pipeline Association	Manila	do	Lease.
Paco Oil Co		do	Do.
Philippine Oil Co		do	Do.
Richmond Petroleum Co	320 Masonic Temple Building, Manila	do	Drilling.
Tayabas Oil Land Association		do	Lease.
Union Oil Co	513 Chaco Building, Manila	do	Prospecting.
Visayan Petroleum Co	Cebu, Cebu	Cebu Province	Lease.
Barclay Petroleum Co		Cotabato Province	Do.
Mindanao Petroleum Co	Zamboanga, Midnanao	do	Do.
Round Mountain Petroleum Co		do	Do.
Anderson, William (association of persons)	c/o Leyte Asphalt and Mineral Oil Co	Leyte Province	Do.

SULPHUR.

Alunan, Gerardo	Silay, Occidental Negros	Silay, Occidental Negros	No production.
Los Valientes	do	do	Do.

IRON SMELTING IN THE PHILIPPINES

By V. ELICAÑO, A. S. ARGÜELLES, and WARREN D. SMITH

INTRODUCTION

It is needless to say that for the last twenty years the agricultural and manufacturing industries in the Philippines have increased considerably. Mining has advanced fairly, but largely in gold and coal production. With the progress of the above industries the demand for iron and steel products has shown material increase, amounting to several millions of pesos annually. The total imports of iron and steel and their various manufactures amounted to 10,023,155 pesos in 1917; 22,464,508 pesos in 1918; 38,621,929 pesos in 1919; and 37,575,421 pesos in 1920.[1] The quantity of the most important products imported during the year 1920 is shown in Table 1.

TABLE 1.

Article.	Quantity.	Value.
	Kilos.	*Pesos.*
Pig iron	2,149,201	170,385
Bar iron	524,320	107,549
Bars or rods of steel	14,486,984	2,842,005
Railroad materials	22,451,041	3,196,580
Corrugated roofing	4,324,336	1,741,230
All other sheets and plates	3,470,774	984,748
Structural iron and steel	7,138,851	1,711,891
Wires and cables	2,578,901	1,133,125
Nails, spikes, and tacks	2,402,863	682,071
Needles, nuts, bolts, washers, rivets, screws, and tools		3,239,926
Pipes and fittings	4,387,395	1,602,384
Total	63,914,666	17,411,894

It will be noted that the local demand for pig iron is very small, and any project for the establishment of a smelting plant in the Islands will have to be developed along the lines of greatest demand. Indeed, a step in this direction has already been taken with the erection of an electric furnace in the shops of the Atlantic Gulf and Pacific Company for making steel castings.

[1] Annual Report of the Insular Collector of Customs for the Year 1920, pages 129 to 147.

The Earnshaw Slipways and the Honolulu Iron Works have also introduced considerable improvements in their foundries in order to meet the needs of their different activities. But these concerns, like all other local manufacturing industries that have installed their own private foundries, are utilizing locally obtained scraps which have to be mixed with imported pig iron.

With the establishment of a local cement factory an impulse will be added to the already recognized popularity of concrete construction in both Government and private building activities, which of course will create a larger demand for reënforcing steel. The wide use of iron roofings, the extension of our railroads, the construction of light industrial railways, and the numerous municipal water and sewage projects now being carried out, all tend to show a prospective development of the iron industry along these lines. There exist in the Islands proved commercial deposits of iron. These should be exploited to counterbalance at least part of the great wealth going out of the country every year.

HISTORICAL REVIEW

Up to the present the only source of iron in the Philippines is from the intermittent operations of native furnaces in Bulacan. Similar to the primitive methods generally practiced in many oriental countries, iron smelting in the Islands between the years 1784 and 1797 appears, from the scant description on record, to have been accomplished first by a reduction of the iron into balls or pasty masses, which must have been somewhat malleable since bolos and other implements were made from them. The present Angat practice is much improved in that the iron is obtained free from slag and can be tapped in liquid form directly from the furnace. The product, however, is all white iron, and only agricultural implements like plowpoints and plowshares are made from it. Much has been written of our native smelting practice,[2] but for the benefit of the reader who has not had the opportunity of reading the papers referred to below, an abstract is given in the following paragraphs:

The furnaces are cylindrical stacks from 2 to 2.5 meters in height and about 1.5 meters in exterior diameter. The upper part of the stack, to a depth of 1.75 meters, is hollow and constitutes the smelting crucible, which is shaped like an inverted truncated cone, circular at the top of the furnace with a diam-

[2] Dalburg and Pratt, Iron ores of Bulacan, Philip. Journ. Sci. § A 9 (1914) 201; McCaskey, H. D., Bull. P. I. Min. Bur. 3 (1903).

eter of about 1 meter, and elliptical at the bottom giving a section of a truncated cone with about 0.5 and 0.2 meter as major and minor axes, respectively. A rectangular runner, about 12 centimeters deep and 13 centimeters wide, pierces the bottom of the crucible from front to back of the furnace. The back end of the runner admits a single tubular clay tuyere, which is connected with the blowing apparatus and through which the blast enters the furnace. The front end of the runner, which is placed a little lower than the rear, serves as a tap-hole for both iron and slag. A block of quartz-sandstone, locally called *batong-buga,* is set in the wall of the crucible over the tap-hole just where the blast, entering through the tuyere from the opposite side, will impinge upon it. The walls of the furnace are soft-burned brick made of clay and set in a mortar of the same clay, which is the residual resulting from the decomposition of the granite found in the region. The sides of the crucible and runner are lined with a mixture of clay and charcoal powder.

The blowing apparatus, or *juncoy,* is a hollow log 35 centimeters in interior diameter and 3.5 meters long; it is fitted with a wooden piston which is edged with soft chicken feathers to prevent leakage of air around it. The piston rod is long enough to permit a full stroke when worked back and forth by hand. The blower is double acting, wooden tubes conducting the blast from valves at both ends of the displacement chamber to the tuyere. In operation the blower lies almost horizontal, one end being raised slightly from the floor to facilitate the work of the operator.

The molds (*hormas*), used for casting the plowpoints and plowshares, are made of clay reënforced by rattan or wire. Each mold consists of a base, which is fixed rigidly to a frame, or rack, and a removable cover, which is made securely fast to the base by a stick placed across the top of the molds with both ends tied to the rack. For convenience in pouring, one end of the rack is raised so that the molds are inclined at an angle of about forty degrees.

The fuel used in smelting is charcoal, usually burned near the smelting plant. A charcoal kiln, or an *inglesa,* as it is locally known, is a rectangular inclosure, the walls of which are made of bamboo poles; it is about 14 meters long, 4.5 meters wide, and 4.5 meters high. The logs for charcoal are cut into lengths one meter shorter than the width of the kiln, and are corded up inside the kiln, leaving half a meter space between the pile and the bamboo walls. Openings which run longitudinally along the floor of the kiln and up one end of the pile are provided, for maintaining a draft. The space around the pile inside the walls is filled with fine charcoal waste, and a cover of the same material is spread over the top. The fire is started at the lower end and gradually burns through the kiln, being retarded by the smothering effect of the charcoal-cover. It requires anywhere from fifteen to thirty days to burn a kiln of 140 cubic meters of charcoal. The charcoal is obtained in unusually large pieces, and is hard and strong.

To "blow in" a furnace, a slow fire is started in the crucible and allowed to burn for several hours; then charcoal is added until the crucible is filled and a light blast is applied. About twenty-four hours after the fire is kindled the blast is increased, and a small quantity of ore, together with more charcoal, is charged at the top of the furnace. Increasingly larger charges are added at intervals until the operation is normal and the furnace is in full blast. Afterwards ore and charcoal are charged together at intervals of from one to five hours, depending on the rate at which the iron comes down. The average charge consists of 43 kilograms of charcoal and 25 kilograms of ore. The ore is broken into pieces with a maximum diameter of about 2 centimeters. When the furnace is working normally, iron is tapped off every three or four hours.

As no flux is added to the charges, the clay lining of the crucible is quickly attacked and eaten away by the charcoal ash, so the smelting continues only as long as the furnace works well or until no more iron can be brought down—ordinarily for a period of from twelve to fifteen days. When siliceous ores are smelted, the life of a furnace is extended to more than twenty-five days. The average capacity of furnace is from 200 to 400 kilograms of metallic iron per day, all of which is made into plowpoints and plowshares. The castings produced are of a uniformly white, fine-grained iron, which is low in silicon, extraordinarily hard, and contains very little graphitic carbon. This should be expected with a furnace of such a short smelting column and with such a blowing equipment, capable only of producing comparatively low temperature.

With the view to interest persons in developing the Bulacan deposits on a larger scale, Mr. Maurice Goodman, of the Mining Bureau, acting in accordance with the recommendation of the former chief of that bureau, Mr. H. D. McCaskey, submitted with his report on the Bulacan Iron Industry[3] a design of an

[3] Publications P. I. Mining Bureau, Ann. Rep. Nos. 4 to 6 (1903–1905).

improved blast furnace for the Angat region, which could be erected at a very reasonable cost, having a capacity of about 10 tons per twenty-four hours. Messrs. Feliciano Nable and R. Hermann incorporated the Angat Mining and Smelting Company in 1914, and operated till 1916; but for some reason the project did not prosper and the company soon passed out of existence.

With the shortage of gray scrap and pig iron during the European war, greatly needed in local foundries, attention was directed to the possibility of producing gray iron from Philippine ores without entailing the expenditure of large capital. Improvement of the native practice was naturally suggested as a possible solution. The Bureau of Science obtained the consent of Mr. Matias Fernando, a mine and smelting-plant owner of Angat, to carry out some experiments in his furnaces. The experiments were started by T. Dar Juan, F. Reyes, and V. Elicaño with the introduction of a mechanical blower, which readily demonstrated its advantage over the hand blower by a slight increase of temperature in the hearth, an increase of output, and decrease of fuel consumption. Further changes, however, were needed, and it was planned to introduce some means of preheating the blast and some changes in the furnace design, but funds were not available to carry the experiments to a successful termination.

Messrs. F. Reyes and T. Dar Juan coöperated also with Mr. M. E. Heacock in his attempts to smelt ore from the Calambayanga deposits. The experiments were carried out in a cupola furnace in a Manila foundry. They were successful in the way a product was obtained; but, like that from the Bulacan furnaces, it was also a white iron. Mr. Heacock continued his experiments in the Army shops at Corregidor, but, on account of certain difficulties and the high cost of transportation of the Calambayanga ore, he made use of the magnetite sand which is found naturally concentrated along Mariveles and Limay beach, bordering Manila Bay. His experiments were successful; and, in consequence, he organized the Manila Iron & Steel Company, to carry out his plans on a commercial scale. This company erected in Bataan a small blast furnace, similar to that designed by Mr. Goodman. Due to small capitalization, the postwar crisis paralyzed the activities of the company.

The Philippine Mining and Industrial Company, a Japanese concern, started the exploitation of the Calambayanga deposits in 1918, but continued its operations only till 1919. The ore was not smelted here but was shipped directly from the mine to Japan.

The National Iron Company, created by the Government to exploit the Surigao (Mindanao) deposits, and the Vamenta Chaves Mining Company, also organized to work a newly discovered iron deposit in Bukidnon, Mindanao, have not yet reported any materialization of their projects.

FUTURE PROCEDURE FOR ESTABLISHING THE IRON-SMELTING INDUSTRY IN THE PHILIPPINE ISLANDS

The ever-increasing demand for iron and steel materials in the Islands in connection with the present trend toward economic and industrial development has occupied the serious attention of technical and industrial men. The apparently immense deposits of iron ores and their exploitation on a commercial scale demand that a thorough study of the steps to be taken in establishing an iron-smelting industry be made. One of the writers, in his recent sojourn in the United States, had an opportunity to get in touch with some of the leading technical men and engineering firms of long experience in the construction and operation of iron-smelting plants. Data and information have been secured with a view of utilizing them as a guide in properly starting an iron industry in a new field like the Philippines.

The following extracts from a memorandum furnished us by one of the largest firms of designing and constructing engineers of blast furnaces in Chicago, Illinois, are published herewith in the hope that they will be of value to those who may be considering the establishment of an iron-smelting industry in the Islands.

A. RAW MATERIALS

Ore.—State the type of ore, whether hematite, magnetite, or limonite, together with chemical analyses and physical characteristics of the ores available for smelting. Sieve test should be included indicating the size of grain or coarseness of the ore, to show whether an ore crushing plant is necessary and to decide the type of blast furnace to be built. Give estimate of cost of ore, f.o.b. cars mine.

State whether the ore supply would be dependable throughout the entire year or whether climatic conditions during the varying seasons would prohibit continuous mining of the ore. In case only intermittent supply of ore is possible, a stock pile of ore would be necessary and one should know for what period ore must be stocked. The most effectual way of supplying information concerning the ores would be to ship representative samples for examination and analyses.

Coke and coking coals.—What kinds of coal are available and what is the chemical analysis of the coal? Has it ever been used for coking purposes? Where? What would be the price of the coal, f.o.b. mines? Is it a dependable supply as to uniformity of grade of coal in the vein, and are the depth of the vein and its extent sufficiently great to assure many years of blast furnace coke supply? In what shape does it come from the mine, in lumps or as fines, and will a crushing plant be required? If coal from several veins is available, it would be well to send representative samples of same for determination of coking properties.

It may be in line to mention at this juncture that through our connection with the most prominent designers and builders of by-product coke oven plants, we would be in excellent position to arrange for the proper by-product coke oven installation best suited to your native or imported coking coals.

Limestone.—Give chemical analyses of limestone available. Indicate price of stone f.o.b. quarry and state whether the quarry would supply a regular grade of limestone.

Scrap.—Is there available in the Islands, and if so at what price, a supply of iron and steel scrap that can be smelted in the blast furnace and in addition to the regular supply of ore? If such supply of scrap is available, at a price approximately one-half to two-thirds of that of pig iron, it can be used in the blast furnace work to great advantage, both as to effecting increase in product and lowering cost of product.

B. SITE

Full information should be obtained as to the relative locations of ore mine, coal mine and limestone quarries, both in reference to their proximity to each other and to their proximity to the proposed blast furnace plant site. A most accurate estimate should be given of the cost of transportation of each of the above three materials from mine or quarry to plant site. There should be furnished for the preliminary study, plans, sketches, photographs and other available information showing the proposed site for the blast furnace plant. There should be indicated whether it is at an inland site or whether it is in conjunction with docks and whether the site has existing or projected railroad connections for shipment of product. In the event that the plant site is not in proximity to principal port of entry, the distance from this port should be stated. The quality of building ground should be stated, whether sand, clay, rock, together with drill tests, so that an idea may be formed as to the proper location of the principal objects of the completed future plant, and of the foundation work which will be necessary.

The elevation of ground above sea level, river or other adjacent body of water and the depth from ground to ground water should be given.

C. LABOR CONDITIONS

State the quantity, quality and efficiency of available labor at the plant site under consideration. State the cost per hour per man for common labor, bricklayers, machinists and if grade of labor such as boiler makers, riggers, structural men, electricians, etc., are available at the Islands, state cost per hour per man for such grades of labor. State number of hours worked per day. State whether labor supply is plentiful, whether unions or class distinctions exist; whether labor is amenable or difficult to handle. Advise whether labor is able of being converted into semi-skilled and skilled operating men. State whether it is possible to draw on existing industrial operations for native foremen, gang bosses and clerical help. State whether technical men of the grade of draftsmen, chemists, mechanical and electrical engineers are available.

D. CLIMATIC CONDITIONS

State maximum, minimum and yearly temperatures, highest velocity and direction of prevailing winds, amount of rains, snow, frost, etc., as well as maximum, minimum and average humidity.

E. WATER SUPPLY

State maximum, minimum and average temperature of water, quality of water, whether fresh, salt or brackish; quantity available, together with chemical analyses if possible, showing permanent and temporary hardness. Elevation of nearest river or other body of water from proposed site to determine how the waste water and sewage of the proposed plant can be disposed of. State whether tide is to be reckoned with and give variations of sea level.

F. BUILDING MATERIALS

Advise cost in Philippine Islands of classes of building material, notably timber, stone, sand, gravel, and brick. If such materials as Portland cement, fire brick, structural steel plate, reinforcing steel, forgings, cast iron, and cast steel are available in Eastern countries at a stated market price, advise these prices.

G. POWER SUPPLY

Comment as to whether electrical power for lighting and power purposes can be purchased locally and at what price, or whether it should be generated at the plant. Is water power available for generation of electric power?

H. CONSTRUCTION AND REPAIR FACILITIES

Is the plant to be located near an industrial city of such size and having such shops so that it will be possible to have repair work done outside of the plant, or will it be necessary to provide for a machine shop, foundry, etc., so that the plant may be entirely independent of outside help.

I. CAPACITY OF PLANT

Is there any preference as to the capacity of the blast furnace or should the capacity of the furnace be predicated upon the character of the ores and the type of metallurgical coke that we believe may be obtained from existing coals? Is there any preference as to the kind of pig iron to be made, that is, high silicon or low silicon foundry grades?

J. GENERAL

What is the selling price of pig iron, f.o.b. wharf, Manila?

From the foregoing it will be seen how exact and comprehensive is the kind of data needed before one can expect to essay the complicated business of making iron on a modern basis. In the following paragraphs we attempt to answer the more important questions in the above memorandum. But even after these are all answered there is the "unknown factor" that enters into all business operations, which only those of long practical experience in the business can foresee.

CHEMICAL AND PHYSICAL CHARACTERISTICS OF PHILIPPINE IRON ORES

Of the known iron deposits in the Philippines, only three have been more or less studied by the Bureau of Science and reported to be of commercial value: the Bulacan deposit,[4] in the vicinity of Angat, Bulacan; the Calambayanga,[5] in Camarines Province; and the Surigao,[6] in Mindanao.

In Table 2 are given analyses of ore from each Philippine locality and of some foreign ores.

TABLE 2.

Constituent.	Bulacan ore.	Calambayanga ore.	Surigao ore.	Mayari ore, Cuba.	Magnetite from Hongkong.	Hematite Mesabi Range, Minnesota.
Hygroscopic water	0.25		13.50			12.27
Combined water			6.60	11.15		
Silica (SiO_2)	5.02	1.02	1.04	2.26	1.20	6.80
Alumina (Al_2O_3)	4.80	1.31	10.56	14.90		2.23
Ferric oxide (Fe_2O_3)	66.41	97.35	66.80	68.75	70.32	
Ferrous oxide (FeO)	20.64		0.36	0.77	22.53	
Lime (CaO)	0.35				0.60	0.32
Magnesia (MgO)	0.74				3.64	0.22
Manganese oxide (MnO)	0.24	0.11			1.48	
Chromium oxide (Cr_2O_3)			1.15	1.89		
Titanium oxide (TiO_2)	0.23					
Nickel oxide (NiO)			None	0.74		
Phosphorus (P)	0.052	0.001	Trace		0.004	0.062
Sulphur (S)	0.02		Trace		0.11	0.07
Total iron (Fe)	62.54	64.14	54.29	48.65	66.75	58.83

The foregoing analyses show that the average iron content of Philippine ores is well within the average smelting requirement. The Bulacan and Calambayanga ores are much richer than the Surigao, but the accessibility of the latter ore and its possible lower mining cost are important points worthy of consideration. With the exception of a few samples, all are within the Bessemer limit as to phosphorus. Sulphur is variable, being high in some samples and low in others, but this element can be controlled by the furnaceman.

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[4] Dalburg and Pratt, Iron ores of Bulacan, Philip. Journ. Sci. § A 9 (1914) 201.

[5] Pratt, Iron ore on Calambayanga, Philip. Journ. Sci. § A 10 (1915) 323.

[6] Pratt and Lednicky, Iron ore in Surigao, Philip. Journ. Sci. § A 10 (1915) 335.

It is important to note that alumina is high in proportion to silica, as compared with the iron ores most widely smelted elsewhere. This fact will perhaps result in the production of high alumina slags, and will necessitate, besides the requisite amount of limestone, increasing the silica in the ore by the addition of barren quartz.

In usual practice ores high in alumina are generally avoided due to the obscure rôle of alumina in the slags, but Mr. J. E. Johnson, jr.,[7] reports the successful experimental operation of a blast furnace, with perfectly satisfactory desulphurization in which the alumina in the slag had been as high as 39.5 per cent, with silica as low as 21 per cent on individual flushes, and averaging for an entire day SiO_2, 24.7 per cent; Al_2O_3, 36.0 per cent; neutral substances (CaS, MnO, FeO, etc.), approximately 3.5 per cent; and CaO, the remainder. Mr. C. M. Weld[8] also states that, in connection with the high alumina and chromium content of the Mayari ores of Cuba, exhaustive studies and experiments on these ores have been carried out by the Pennsylvania Steel Company, and that it has been announced that all the difficulties have been solved, and steel rails of more than usual excellence have been manufactured from them. It might, therefore, be conclusively stated that the special high alumina characteristic of Philippine iron ores does not prevent them from being smelted successfully. It has already been stated that the character of the Surigao ores, except for the absence of nickel, is similar to that of the Mayari ores.

Titanium is present in some of the Bulacan ores, but in such quantities as would not affect the operation of a blast furnace nor the grade of the iron produced.[9]

The ores of Bulacan consist of magnetite and hematite in intimate mixture, but of varying proportion.[10] Both minerals are usually massive, although some specular hematite is sometimes encountered. The Calambayanga ore is almost pure hematite with traces only of magnetite.[11] The hematite is massive or granular, and the ore is moderately soft and very porous or vesicular. Therefore, from the peculiarities above described, the

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[7] Johnson, J. E., jr., The effect of alumina in blast furnace slags, Bull. Trans. Am. Inst. Min. Eng. **44** (1912) 128.

[8] Weld, C. M., The residual brown iron ores of Cuba, Bull. Trans. Am. Inst. Min. Eng. **40** (1909) 312.

[9] Rossi, Auguste J., Titaniferous ores in blast furnace, Bull. Trans. Am. Inst. Min. Eng. **21** (1892–3) 832.

[10] Dalburg and Pratt, op. cit.

[11] Pratt, op. cit.

formation of fines might be expected, in more or less considerable quantity, which must receive preliminary treatment before being charged into a furnace. Several processes [12] of agglomerating ore fines are known, either with or without the use of heat. It remains only for the operator to adopt the one that is most suitable and that can be run most economically in conjunction with the smelting-plant equipment.

The Surigao ore offers an entirely different problem. It is principally ferruginous clay, but contains also an abundance of small, round pellets of hydrous iron oxides, as well as fragments or crusts of the parent rock, much altered, porous, and iron-stained, but maintaining their original form. The ore is soft and very spongy, or mealy.[13] To utilize this ore, sintering or nodulizing is necessary, and some means of separating the intermixed fragments of barren rocks will have to be provided.

MINING COSTS

The present exploitation of the Bulacan deposits does not develop them at all, nor has the work done on the Calambayanga revealed much of the character of the deposit, which cannot be accurately determined without core drilling. It is, therefore, dangerous to advance even a tentative estimate of the mining costs until more exploratory and development work has been done. Pratt and Dalburg noted that the walls of the ore bodies in Bulacan are invariably soft; similar conditions are found in Calambayanga which will require a great deal of underground timbering, a very expensive item in mining costs in the Philippines. The Surigao deposit has been more or less thoroughly studied and its mode of occurrence makes its mining less problematic than the former two; an estimate of the cost could be fairly calculated after having decided upon the kind of excavating and transportation equipment to be used.

Unless a smelter is built near the mines, the transportation of the ores from the mines to a place where shipping facilities can be obtained, either to local or to foreign smelters, is a problem that must be solved by the prospective operator. The deposits of Surigao and Calambayanga are near points that can be developed into good harbors.

The Bulacan deposits are isolated in a mountainous region about fifty or more kilometers from a railroad line. The sharp

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[12] Johnson, J. E., Principles, Operation and Products of the Blast Furnace, 1st ed. p. 193.

[13] Pratt and Lednicky, op. cit.

relief of the region will require considerable expenditure, because the region is subject to sudden flooding by the streams during the rainy season. Aërial-cable transportation will probably be the most convenient.

Labor is scarce in all three districts, as most of the people are engaged in agriculture and they cannot be depended upon for continuous work in the mines. The timber supply in two of the districts is not abundant, either for fuel or construction. At Calambayanga there is plenty.

FUEL SUPPLY

Deposits of coking coal are found in Cebu, and at Sibuguey, Mindanao. Exploitation has been started in these fieldss, but only on a small scale. Development of the coking seams is not very extensive and the probably available quantity is still unknown. It will take a year or two still to place either one of the districts on a producing basis capable of supplying continuously a blast-furnace plant.

For charcoal supply we might count upon the extensive forests of Zambales, Bataan, Tayabas, Mindoro, Negros, and Mindanao. It would seem, however, hardly probable that, with the increasing popularity of Philippine lumber in foreign countries, these forests could be considered more valuable as blast-furnace fuel supply than as timber supply, particularly when it is known that once the primary forests are destroyed they never return.

Semianthracite is also being mined at Malangas, Mindanao; but, like the other fields, this one is still only partly developed. This can be considered as a possible fuel supply for blast-furnace smelting.

FLUX SUPPLY

On account of the low silica content of the Philippine iron ores, silica flux might probably be needed in addition to limestone, as has been mentioned. A good supply of both limestone and silica can be found not far from the ore deposits, all of which could be transported together with the ore. There exists also a good supply of limestone and of siliceous tuff near the coal mines of Cebu.

POWER SUPPLY

Power can be either steam or hydro-electric. For the use of the former the locations of fuel supply have already been mentioned; for hydro-electric development the following are pointed out: Agus River in Mindanao, Angat River in Bulacan (Luzon), and Agno River in Pangasinan (Luzon). A report on the power possibilities of Agus River has been submitted by Chas. Bradshaw, formerly of the Bureau of Public Works, and is in the files of that bureau. Seven possible power sites are mentioned, with heads varying from 160 to 400 feet, and the total available power is about 300,000 E. H. P. at a prewar cost of from 40 to 90 pesos per E. H. P. installed. Gen. C. de las Heras, in a paper read before the Manila Merchants' Association in May, 1912, described several ways of developing hydraulic power in Angat River, and he estimated that 11,400 E. H. P. could be developed at a cost of about four and a half million pesos. The Bureau of Public Works has at present under investigation the possibility of developing Agno River, which is said to be capable of furnishing one million horsepower.

SMELTING PROCESS

With the present 2-peso tax levied on every ton of ore exported from the Islands, it seems doubtful whether the exploitation of our iron deposits by smelting the ore outside the Islands will be a commercial success. For the production of metallic iron at home either blast furnace or electric smelting is suggested. It is impossible to make a close comparison of the advantages and disadvantages of the two processes in the present stage of development of our fuel and hydro-electric power supplies. More extensive survey and study of their possibilities are needed in order to make a fairly close estimate of these processes. Other factors, such as the capacity of the plant, selection of site, disposal of by-products, relation to development of other industries, and many other points have a great bearing upon the matter of deciding which of the processes is the more advantageous.

MISCELLANEOUS POINTS

There are several points mentioned in the memorandum given above which will not be discussed in detail in the present article because they depend much on local and on time conditions. The quantity and quality of water supply and the climatic conditions depend upon the site selected; data covering the specific points mentioned in the memorandum for the chosen site will be found in the publications of other Government entities.

Mention has already been made of the great improvements introduced in the shops of the Atlantic Gulf and Pacific Company and the Earnshaw & Honolulu Iron Works which give these companies better constructing and repairing facilities.

In connection with building materials it might be said that almost all kinds are available in the local market, but during this reconstruction period prices are changeable. The amount of iron and steel scraps obtainable is not large, and we believe that it would not affect much the cost of smelting operations in the Islands.

DEVELOPMENT

There are three ways by which the development of this industry can be fostered:

1. By the establishment of a smelting plant by a company of long experience in the iron industry abroad.
2. By a local company that is already engaged in closely related lines of activity, such as the Earnshaw & Honolulu Iron Works and the Atlantic Gulf and Pacific Company.
3. By the Government starting the industry with the plan of eventually turning it over to a private company.

The first procedure is rather problematical in view of the fact that it would be rather difficult to interest companies abroad who are not familiar with local conditions. The present demand for capital all the world over is so great that considerable inducement will have to be made by the Government in order to attract a well-established company abroad to extend its operation here. Therefore this plan cannot be depended upon to start a local iron industry in the near future.

The second procedure, which calls for the encouragement of local companies engaged in activities closely related to the iron industry, would appear to hold better promise of rendering immediate results in establishing the industry. A local company could start on a very small scale and gradually build up the industry. This would be a safer course to follow, because knowledge of local conditions, such as labor, fuel supply, sources of material, markets, etc., will greatly help in guiding the industry along proper lines.

The third procedure, which depends upon Government initiative, should be followed in the event that neither of the above-cited possibilities could be depended on. In this case the Government should gradually build up the industry along the lines indicated above and, whenever there are private corporations ready to undertake the development of iron smelting, it should be turned over to private enterprise. Past attempts along this line have not been successful, nor altogether creditable to the Government, and this method should be a last resort. The defects in a government-operated business are too obvious to require further elucidation.

The following plants in the United States were visited recently by one of the writers; the Bureau of Science would gladly help any interested persons to secure further information along the various specialties indicated:

Jones & Laughlin Steel Factory, South Side, Pittsburg, Pa. (steel products).
Jones & Laughlin Blast Furnace, Oakland, Pittsburg, Pa. (pig iron).
American Sheet & Tin Plate, Vandergrift, Pa. (galvanized iron sheets).
American Sheet & Tin Plate, New Kensington, Pa. (tin plate).
Carnegie Steel Factory, Duquesne, Pa. (steel products).
National Tube Co., McKeesport, Pa. (tubes, steel rods, wire, etc.).

CONCLUSIONS

That there is more than an adequate iron ore supply in the Philippines cannot be gainsaid. Furthermore, while other considerations such as fuel, labor, etc., present some difficulties, none of them is serious enough to prevent the development of the industry, once the need for a local supply of iron and steel becomes acute.

There are, however, some larger aspects of commercial and military strategy which are very greatly dependent upon iron; these can be merely hinted at here but, at the same time, they cannot be overlooked.

In the first place, as regards the commercial side of the subject, it must be borne in mind that in both Asutralia and China vast iron-smelting programs are under way, and plans are projected in Celebes for the building up of a large industry by the Dutch authorities. It is apparent that it will be risky to count on any market outside the Philippines.

With reference to the military aspect, we need only remind the reader that iron is one of the chief (if not the chief) sinews of war. A survey of the mineral supplies of the Far East reveals the fact that at least one powerful country needs and must have iron.

PETROLEUM AND RESIDUAL BITUMENS [1]

By WARREN D. SMITH

Petroleum seeps in the Philippines have been known for many years, dating back to Spanish times. In view of the production of petroleum in commercial quantities in Borneo to the southwest, and Formosa (though in much smaller quantities) to the north, and the worldwide demand for petroleum and its products, great interest in the Philippines as a possible producer is natural. The result of the present operations of the Richmond Petroleum Company on Bondoc Peninsula is of more than local interest. The securing of a commercial supply of oil in this Archipelago will have a profound effect upon affairs political and military as well as commercial.

The principal source of oil in the Philippines is the group of shales, with intercalated sandstone and limestone beds, which have been given the name of Vigo, from the type locality on Vigo River in Bondoc Peninsula.

The typical oil shale on Bondoc Peninsula may be described as consisting [2]—

> Of fine-grained shale and sandy shale interstratified in thin regular beds from 5 to 10 centimeters in thickness. Occasional beds of sandstone occur varying from 10 centimeters to 1 meter in thickness. The fine-grained shale is gray, blue, or black, and is made up almost entirely of clay. * * * The blue or black, fine-grained shale in the Vigo formation usually emits a slight odor of light oils upon fresh fracture, and in some outcrops is highly petroliferous. The material loses this odor and assumes a light gray color after it has been exposed to the air and has become thoroughly dry.

These shales contain numerous Foraminifera of the genus *Globigerina*, which may be the source of the oil. Although present numerously, these organisms did not appear to the writer to comprise any large percentage of the volume of these shales. However, shales from Leyte and Mindanao contain them in very great numbers.

[1] Some of the information contained in this summary has been taken from earlier articles by Wallace E. Pratt and the writer.

[2] Pratt, W. E., and Smith, W. D., Philip. Journ. Sci. § A 8 (1913) 331.

These Vigo shales are found to be hundreds of meters in thickness in several parts of the Islands, and much thinner in others. The age of the shales is middle Miocene, and they are easily recognized by certain index fossils. Some of the most characteristic are the globular protozoan, known as *Globigerina;* a small bivalve shell known as *Corbula socialis;* a flat-topped cone shell known as *Conus ornatissimus*; another gastropod, or snail, with a high spire and very much tuberculated, known as *Cerithium jenkinsi*; and a much-coiled cast of a worm borer known as *Vermetus javanus*. These fossils are well known in connection with the similar shales of Java. Specimens of these may be seen in the Bureau of Science collection.

The Canguinsa sandstone, a buff-colored, very porous, and somewhat tuffaceous formation above the Vigo, may prove to be the reservoir for holding the oil.

STRUCTURE

It has long been known that an important condition for the accumulation of commercial supplies of oil is the anticline (arched flexure of the rock strata), or the dome, which is formed by cross-folding. In southern Sumatra, according to one authority, no oil has been obtained in commercial supplies except by boring on the crest of anticlines. The double flexure, where the anticline plunges at both ends, forming a dome, affords the most ideal conditions. By no means all of the productive wells in the world are located on anticlines, but in new country it is desirable to locate the most favorable structures for "wildcatting."

LOCATION OF PROSPECTS

The chief seeps and most promising prospects are located as follows (see map, Plate 2):

1. Bondoc Peninsula (lower end), Tayabas Province, southeastern Luzon.
2. The Ozocerite veins near the town of Villaba and the asphaltic tuff near Baliti, both on the northwestern part of Leyte Island.
3. Pidatan district, in central Mindanao.
4. The west coast of Cebu Island, from Alegria north to and perhaps beyond Toledo.
5. Natural gas from some deep wells in Tertiary shale on the eastern flank of the Cordillera and the low country to the east on Panay Island.

Other seeps have been reported from the southern end of Mindoro and from Siasi Island.

All the known oil seeps, petroleum residues, and natural gas emanations in the Philippines are associated with Tertiary or later sediments.

SPECIAL LOCALITIES

BONDOC PENINSULA, TAYABAS PROVINCE, LUZON [3]

The seeps are in highly inclined and, to a certain extent, faulted strata, which are probably in all cases part of the structure of anticlinal folds. From this association it is believed that the petroleum in this field has, in accordance with the general law of petroleum accumulation, tended to collect in the crests of anticlines.

The petroleum occurs, associated with certain horizons, in an extensive series of beds of sandstone and shale (Vigo shale), which is similar in character to the oil-bearing rocks of productive fields, notably those of Japan. The principal seeps are found in the upper part of this series in a zone designated as the Bacau stage, which is predominantly shale but which contains subordinate beds of sandstone. In its seepage, the petroleum is associated with the shale rather than with the sandstone, and may be observed in some cases to come directly from the shale. Beneath the surface, where closed lenses of sandstone probably exist, one would expect to find the principal accumulation of petroleum in the more open, sandy zones. At the surface the light oil appears to have escaped readily from the coarse-grained beds, and to have been retained only in the fine-grained shale.

The structure of Bondoc Peninsula includes a number of anticlinal folds, and the conditions along some of these anticlines are considered favorable for the accumulation and retention of petroleum, whether it occurs in all or in any one of the horizons at which it is suspected to occur.

The following localities are considered some of the more promising as sites for the location of "wild-cat" wells to explore the petroleum-bearing rocks of Bondoc Peninsula. However, owing to conditions discussed in the full report, published in the Philippine Journal of Science, it is possible that oil may be encountered at any one of the sites, even though it be absent elsewhere. There are many places other than those listed which would be considered as favorable in case exploration of any of the sites herein recommended prove successful.

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[3] See Bureau of Science Press Bulletin No. 97, November 12, 1920.

Locality No. 1.—The Maglihi anticline in the southeastern part of the peninsula, near Mount Morabi.

Locality No. 2.—The Maglihi anticline in the valley of Bahay River.

Locality No. 3.[4]—The Central anticline in the vicinity of Balinsog or Bacau.

Locality No. 4.—Ayoni anticline, about 1,500 meters inland from the mouth of Ayoni River on the west coast.

Locality No. 5.—The Malipa anticline, near Cabongahan.

LEYTE

It has been known since 1890, at least, that petroleum existed in Leyte Island, near the town of Villaba, on the northwest coast.

Rock asphalt was discovered in 1912 by a Filipino forest ranger, and there followed a period of active claim-staking. Not until the year 1918, however, was the deposit opened up commercially.

The extreme northwestern peninsular portion of Leyte, as far south as Baliti, is worthy of careful exploration. The geological formations here are, according to Pratt, a continuation of those on Bondoc Peninsula.

In Leyte, petroleum is encountered at two places: it seeps from the upturned edges of the Vigo shale, and oozes from the base of a hill which consists of a clayey tuff-sandstone belonging to the Canguinsa. Residual bitumens occur in the Canguinsa and in the Malumbang series; one questionable outcrop of solid bitumen was observed, loose débris, which appears to overlie the Vigo shale; and a heavy, black oil, or viscous bitumen, was found in sandstone near the base of the Vigo.

The bitumens in the Canguinsa are encountered in five types of deposits: (1) Solid bitumens, in lenses or pockets which tend to follow bedding planes, but which also cross the bedding irregularly along fractures and cavities; (2) solid bitumens in regular fissures, which penetrate the clay-tuff independently of bedding planes; (3) in nonuniform mixtures of bitumen-impregnated, clay-tuff fragments and subordinate solid bitumen; (4) viscous, or semiliquid, bitumen-cementing breccias of flintlike

[4] Recent work has shown that the structure of this, as represented in earlier reports, needs modification, and parts of it do not appear to be altogether suitable. The Richmond Petroleum Company of California, a subsidiary of the Standard Oil Company, has drilled one hole to a depth of about 400 meters which caved on the Amuguis anticline just to the south of the central anticline. The rig has been moved (September, 1921) about 3 kilometers farther north, higher up on the structure.

limestone, small domes of which protrude from the surface of the clay-tuff formation; and (5) viscous, or semisolid, bitumen filling the centers of hollow, cylindrical concretions, which occur in the clay tuff, with their longer axes nearly vertical and at right angles to bedding planes.

The bitumen in the Malumbang series has impregnated porous limestone and sandstone, forming what is known commercially as rock asphalt.[5] It is this material impregnating the porous limestones of that region which the Leyte Asphalt and Mineral Oil Company is developing. The deposit is apparently of considerable size.

MINDANAO (PIDATAN DISTRICT)

The Pidatan field was investigated by the writer late in February of 1921, in company with Pittsburg (Pa.) oil men and geologists. About one week was spent on the ground in the vicinity of the petroleum seep. It was the consensus of the entire party that the immediate vicinity of the seep did not show sufficient indications to encourage drilling in that particular region, but it did seem justifiable to consider further geological exploration in the surrounding territory in Cotabato Province.

The field investigated is situated about 60 kilometers due north of Fort Pikit, Cotabato Province, which in turn is situated some 70 kilometers up the Rio Grande de Cotabato and, therefore, is very nearly in the heart of the great southern island. To the north of the field lies the volcanic range containing the active volcano of Mount Ragang, which in turn lies just back of Lake Lanao. To the west runs the line of hills and mountains known as the Babuy Mountains. To the east there are some moderately high hills and mountains of limestone, of which Mount Kitubud is the outstanding feature. The principal stream running through the field is the Malitabug, which flows almost due north and south. This is a swift and almost unfordable tributary of the Rio Grande.

Transportation to the seep is first by launch from Cotabato to Fort Pikit, thence by horse and cargadores up Malitabug River, thence across country to within about 1.5 kilometers of the oil seep, and the rest of the way on foot. The trail as far as the forks, close to Banisilan, is a fairly good one; from here on it ascends gradually to an elevation of between 750 and 900 meters, and is exceedingly rough in places. The country is practically

[5] Most of this so-called asphalt is a paraffin residuum corresponding most nearly to ozocerite.

uninhabited and side trails are few. High grass (cogon and talahib) runs riot, and much of the country is fairly deforested. With the exception of Banisilan, where there are a Constabulary outpost, and a Moro farm school under the able supervision of Mr. Manion, there is no settlement worthy of the name.

The geology of the region, briefly stated, is as follows; The principal formation as indicated on an early map published by the Division of Mines consists of Tertiary sediments, limestones, sandstones, and shales. These are intruded on the edges of the field by igneous rocks, principally basalts and andesites. There is considerable agglomerate in the region. Owing to these intrusions, and also to more widespread regional earth movements, the sediments have been folded and faulted, as in other parts of the Archipelago; some of them, especially the lower series, including the Vigo shales (the petroliferous horizon of the Philippines), very profoundly. In the region adjacent to the seep the formations which might be counted upon to contain oil are so badly disturbed that no regular structures could be made out; and, as this is the crux of the whole matter in an oil field, a favorable consideration of this locality cannot be entertained. This does not mean that oil does not exist there: it might even be there in fair quantity; but with other difficulties, already referred to and which must be considered, it does not promise to be an economic proposition. This is a feature which many would-be oil producers do not adequately consider. The location of the seep and the composition of the oil, which has none of the light fractions and very little either of paraffin or of asphalt, both indicate very local and abnormal conditions.

The seep itself is located in a small ravine, the headwaters of Kirusoy Creek, a tributary of the Malitabug, well up on the side of a partially wooded range of igneous rock and on the south side of an east-west dike running off from the main igneous mass. Apparently, there is a fault at this point, as the oil is seeping out along a considerably slickensided surface. On the hanging wall there is a very much broken mass of material, which may be either agglomerate, locally brecciated igneous rock, or merely talus. The amount of oil and gas issuing at this point is very small. Compared with other seeps seen in other parts of the world by members of this party, the seep was quite disappointing, and the writer urges upon the investing public extreme caution in considering this region as a possible oil producer. To practical and experienced oil producers, this advice is not necessary.

CEBU

Just prior to the outbreak of the Insurrection of 1896 an English company had started drilling on the Smith Bell Estate near Toledo, Cebu, but with the coming of hostilities the work was abandoned when the bore had reached about 400 meters. A small amount of oil had been tapped, and it can now be baled from the old well.

Although there are several strong seeps on the west coast of Cebu, the geologic conditions are apparently not so favorable as on Bondoc Peninsula. At Alegria on the southwestern coast the seep is located near a fault in a very sharp fold, and the topography is such that drilling operations would be expensive. Farther north, at the old Smith Bell well near Toledo, the rocks are found in a monoclinal attitude in which there are minor folds. Detailed work in that region has revealed some unfavorable structural features. However, between these two localities, or farther to the north of Toledo, favorable structures might be located.

MINDORO

Two seeps are reported on Mindoro—one near Mangarin, and the other farther back in the foothills to the northeast of this place. The writer knows nothing at first hand of either of these localities and, as far as he knows, nothing favorable has been reported with reference to them.

PANAY

On Panay Tertiary shales yielding natural gas are found on the eastern flanks of the main cordillera, generally monoclinal; that is, dipping in one direction to the east. From work already done in that region it is known that there is at least one well-defined local anticline, known as the Maasin anticline, which might be a favorable location for a test well. However, it should be stated that some comparatively deep artesian wells in that region, which have reached a depth of 527 meters, have shown so far only small amounts of natural gas, apparently marsh gas and salt water.

SULU GROUP

A petroleum seep is reported by observers of the Coast and Geodetic Survey on Siasi Island, in the Sulu group, between Jolo and Tawitawi. The writer is doubtful of the genuineness of this seep since there is a great amount of volcanic veneer on those islands. However, this does not preclude the possibility of finding Tertiary sediments beneath.

TABLE 1.—*Physical and chemical properties of Philippine petroleum.*[a]

Description of petroleum.	Crude oil.		Distillation products.						Residue above 400° C.	Remarks.
	Color by transmitted light.	Specific gravity.	Gasoline, to 150° C.		Kerosene, 150° to 300° C.		Heavy oils, 300° to 400° C.			
			Volume.	Specific gravity.	Volume.	Specific gravity.	Volume.	Specific gravity.		
Tayabas Bahay well I., depth 40 m. Sampled by division of mines 24 hours after well had been drained.	Brown to wine red.	0.8325	39.0	0.770	44.5	0.850	16.5	------	------	Flash point 0° C. (32° F.) sulphur absent; initial boiling point, 91° C., paraffin, 8.1 per cent; specific gravity at 15° C.
Cebu, P. I.:										
Well at Toledo, Cebu	Dark brown	0.885	6.2	0.762	42.32	0.832	38.3	0.901	13.17	Residue above 375° C.; specific gravity at 15° C.
Oil seep at Alegria, Cebu	do	------	17.5	------	30.5	------	35.0	------	------	Residue contained foreign sediment.
Leyte, P. I	------	0.926	------	------	------	------	------	------	------	Flash point 74° C. (166° F.).

PIDATAN, MINDANAO.

Specific gravity at 15.6° C	0.9257.
Distillation:	
Light oils (below 150° C.)	None.
Burning oils (150°-300° C.)	45 per cent by volume.
Heavy oils (300°-400° C.)	49.5 per cent by volume.
Residue	5.5 per cent.
Sediment	Large amount.
Water	Trace.
Base	Paraffin.
Main calories or gross heating value	12,495.
Available heating value	11,189.
Sulphur	1.56 per cent.

[a] Analyses by Richmond and other chemists of the Philippine Bureau of Science.

CHEMICAL AND PHYSICAL PROPERTIES OF PHILIPPINE PETROLEUM AND NATURAL BITUMENS

Philippine petroleum has a paraffin base and is usually reddish to violet in color. It is quite clear, and closely resembles oil from Burma and Sumatra. Table 1 gives a fairly complete analysis made by Richmond, and other former chemists of the Bureau of Science. Table 2 contains an analysis of the petroleum residues from Leyte Island. The paraffin content of Philippine petroleum is very high; a bottle full of oil which one of the geologists collected in 1908 from the Toledo well, and put, imperfectly sealed, into one of his saddle bags, was found, on unpacking three days later, to contain no oil; but it was half full of solid paraffin.

TABLE 2.—*Physical properties of natural bitumens from Villaba, Leyte.*

Property.	Outcrop A and B.
Specific gravity	1.05
Hardness	2.00
Color	Jet black.
Streak	Black.
Luster	Brilliant.
Structure	Columnar.
Fracture	Conchoidal.
Flows	Intumesces, softens, and flows imperfectly at 150° C.

CONCLUSIONS

1. That there is a very high grade of petroleum in the Philippine rocks is proved beyond question.

2. The source of this oil appears to be in the Vigo shales which contain microscopic organisms of a very simple structure, known as Foraminifera. No diatoms, such as are associated with the Californian deposits, have so far been seen in the Philippine shales.

3. In several parts of the Islands, notably Bondoc Peninsula, the structure appears to be quite suitable for the accumulation of commercial supplies of oil.

4. The kinds of rocks and structure, as well as the oil contained in them, are very similar to those of Sumatra, Burma, Formosa, and Japan.

5. The quantity of petroleum is unproved and can be proved in only one way; namely, by drilling.

6. In view of the world-wide shortage of petroleum and its products, competent and financially able concerns would be justified in doing "wild-cat" work in the Philippines.

There are sixteen petroleum lease applicants in the Philippines, but only two companies have done much exploratory work and only one, the Richmond Petroleum Company, a subsidiary of the Standard Oil Company of California, has carried on large-scale boring operations. Their first hole, located on a structure on Bondoc Peninsula, Tayabas, Luzon, was not successful though a slight "show" of oil and gas was obtained. This company has three geological survey parties in the field in various parts of the Archipelago.

PETROLEUM LEGISLATION

At the end of this bulletin we have included the latest amendments to the Petroleum Regulations. The revised regulations have already been printed and issued by the Department of Agriculture and Natural Resources.

AMENDMENTS TO THE RULES AND REGULATIONS GOVERNING THE LEASING OF PETROLEUM LANDS

3. (*b*) A plan of the land in triplicate if the survey thereof has already been approved by the Director of Lands, or a sketch of the same showing its area, shape, and boundaries. The tract applied for must be in a single mass, as far as practicable rectangular in shape.

5. (*d*) A clause that within three years from the date of the lease the lessee shall cause the premises to be surveyed if no previous survey thereof has been made, and upon approval by the Director of Lands shall deliver to the Secretary of Agriculture and Natural Resources, in triplicate, the technical description and plan of such survey to be attached to the contract of lease in amendment or substitution of the description contained therein.

5. (*e*) That the lessee agrees to commence boring a well upon the premises leased or upon an adjoining lease in the same geological terrain, granted to the same applicant, not later than eighteen (18) months from the date of the lease, provided that when the leasehold is beyond twenty-five (25) kilometers from the coast by the most direct feasible route, the time limit for the commencement of boring operation shall be extended to three (3) years. The lessee shall pay rental to the Government, during the period of the lease, until boring operations are commenced at the following rates:

For leaseholds *within* twenty-five (25) kilometers from the coast by the most direct feasible route:

	Pesos per hectare.
First year	0.00
Second year:	
First semester	1.00
Second semester	4.00
Third year	5.00
Fourth year	5.00
Fifth year	5.00

For leaseholds *beyond* twenty-five (25) kilometers from the coast by the most direct feasible route:

	Pesos per hectare.
First year	0.00
Second year	1.00
Third year	1.00
Fourth year	5.00
Fifth year	5.00

Upon the failure of the lessee to commence boring a well as provided herein, the lease shall be considered rescinded and the land described therein shall be subject to lease to any other party by the Secretary of Agriculture and Natural Resources, unless said Secretary shall, for justifiable reasons, decide to permit the continuation of the lease.

5. (*f*) That in the event of the successful development and operation of the aforesaid leasehold, the lessee shall deliver as royalty to the lessor at the well, part of the oil produced and saved at the following rates:

For leaseholds *within* twenty-five (25) kilometers from the coast:

	Per cent.
With a monthly production averaging 50 barrels or more per well per day	12.5
With a monthly production averaging less than 50 barrels per well per day	10

For leaseholds *beyond* twenty-five (25) kilometers from the coast:

	Per cent.
With a monthly production averaging 50 barrels or more per well per day	10
With a monthly production averaging less than 50 barrels per well per day	8

The rates of royalty herein provided shall be based upon the amount of oil produced and saved, excepting such oil as is used by the lessee in its operations on the premises, which shall be free from royalty.

The distances referred to in this section shall be measured from the nearest producing well within the leasehold to the coast by the most direct feasible route.

The barrel used as a unit of measurement shall be the standard of forty-two (42) United States gallons equivalent to 158.988 liters.

In the case of production of oil by any well situated on land of private ownership within the premises described in the lease, the royalty due to the lessor on such production shall be reduced by 40 per cent of the same; Provided, however, that such reduction shall be effective only to the extent of like royalties delivered or paid by the lessee to the owner of such land. Until the lessor shall otherwise elect, the lessee shall purchase the share of oil belonging to the lessor at the reasonable market price at the well, payable at the end of each quarter year. All royalty payments shall be accompanied by sworn reports justifying the same.

ADDITIONAL RULES AND REGULATIONS COVERING THE GRANTING OF EXCLUSIVE RIGHTS OF GEOLOGICAL EXPLORATION FOR PETROLEUM OR OTHER MINERAL OILS AND GAS, PRESCRIBED BY THE COUNCIL OF STATE UNDER THE PROVISIONS OF ACT NO. 2932 OF THE PHILIPPINE LEGISLATURE.

1. *Leases for Geological Exploration.*—Any person, corporation, association, or partnership qualified under the provisions of Act No. 2932 of the Philippine Legislature, or of any amendments thereof, may be granted an exclusive lease of public lands for geological exploration with respect to petroleum or other mineral oils and gas, within a specified area, by filing an application therefor addressed to the Secretary of Agriculture and Natural Resources, through the Director of Lands.

2. *Areas for Exploration.*—Exploration areas shall be leased in blocks or tracts of not more than four hundred (400) hectares for each individual, and not more than one thousand two hundred (1,200) hectares for any corporation, association, or partnership. The Secretary of Agriculture and Natural Resources may, however, at his discretion and for justifiable reasons, grant more than one exploration lease to any one person, corporation, association, or partnership.

Unless otherwise expressly stated in the contract of lease, the areas granted thereunder for geological exploration shall not include the following:

(*a*) Mineral reserves, patented claims, and mining concessions of petroleum and other mineral oils and gas.

(*b*) Leases granted or applied for under Act No. 2932, and the rules and regulations prescribed pursuant thereto.

(*c*) Reservations for public or quasi-public purposes, including military and navy reservations, unless with the written consent of the authorities having control and administration of such reservations.

3. *Application for Exploration.*—An application for an exclusive right to explore for petroleum or other mineral oils and gas within a given area, must be subscribed and sworn to by the applicant or a duly authorized representative, setting forth:

(*a*) The name and post-office or business address of the applicant, stating in case of an individual, his age, citizenship and cedula number for the current year, giving date and place of issue; in case of unincorporated association, the name, age, citizenship and cedula number for the current year of each member thereof, stating the date and place of issue of such cedula; and in case of a corporation or registered partnership, a certified copy of the articles of incorporation or copartnership must be attached to the application, provided that the Secretary of Agriculture and Natural Resources in his discretion may grant a reasonable length of time for the filing of such articles of incorporation or copartnership, but in no case shall such extension be for a period of more than six months after the filing of the application.

(*b*) As accurate a description of the land applied for as may be given, stating its area, the province, municipality, barrio, or sitio where it is located, and its limits and boundaries, specifying those having reference to natural objects and accidents of the ground or permanent monuments, if any. If the land has already been surveyed, it would be sufficient to state the number of the survey and the municipality and province where the land is situated.

(*c*) The names and addresses of all owners, occupants, and claimants of lands or rights in lands within the area applied for, so far as known to the applicant.

(*d*) That the application is made for the exclusive use and benefit of the applicant and not, either directly or indirectly, for the benefit of any other person or persons, corporation, association, or partnership, and that the lease is sought in good faith for the sole purpose of geological exploration.

(*e*) Any interest of the applicant, if any, and of every member of an applicant corporation, association, or partnership, in other leases granted under Act No. 2932 or in applications for such leases.

(*f*) Reasons why the land is believed to offer a favorable field for geological exploration and that it is not within any known geological structure of a producing oil or gas field.

(*g*) Where two or more tracts or blocks are sought to be leased by the same applicant, the matter may be presented in a single application, provided that the information required under this section shall be set out in the application with respect to each tract or block sought to be leased; and in such case all tracts or blocks included under the same application may be secured under one contract of lease and a single bond accepted in an amount corresponding to the combined areas of all tracts or blocks included in the same lease.

4. *Papers to Accompany the Application.*—The application must be accompanied by the following papers:

(*a*) A lease contract in triplicate, prepared in accordance with the form prescribed by regulation.

(*b*) A bond as required by regulation.

(*c*) A plan or sketch of the land, showing area, dimensions, and boundaries and its relative position with respect to natural features, or other means of identification.

5. *Procedure after Filing the Application.*—Upon receipt of the application, the Director of Lands shall examine the same and

all the accompanying papers, and if he shall find them properly executed in accordance with these rules and regulations, he shall then forward them, with his comments and recommendations thereon, to the Secretary of Agriculture and Natural Resources.

6. *Form, Terms, and Conditions of Geological Exploration Leases.*—Exploration leases shall be executed in substantially the following form and must contain the terms and conditions herein specified.

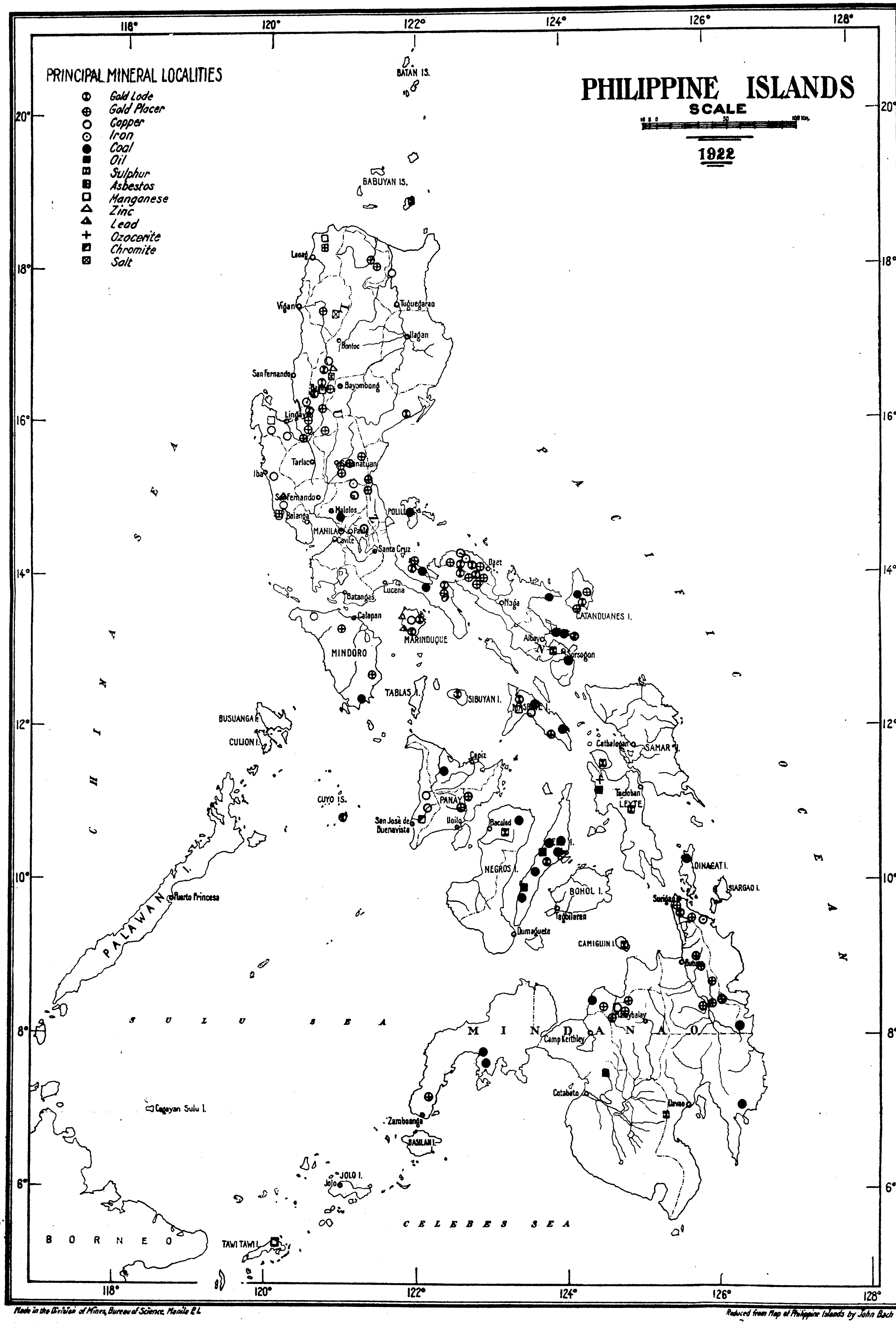

PLATE 2. THE PHILIPPINE ISLANDS, SHOWING MINERAL LOCALITIES.

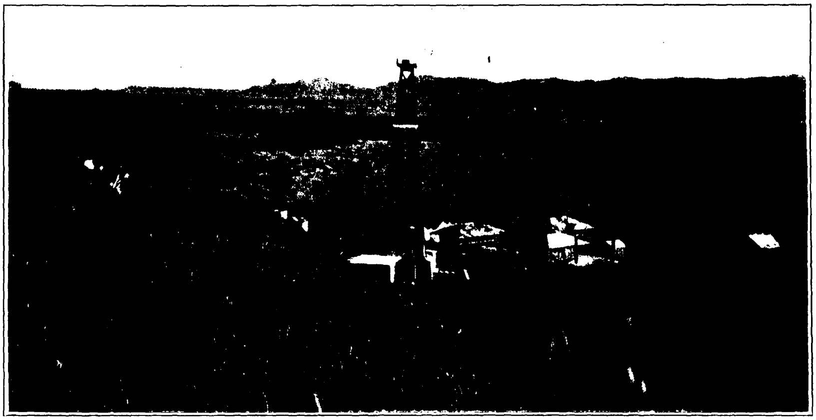

Fig. 1. Richmond Petroleum Company's derrick.

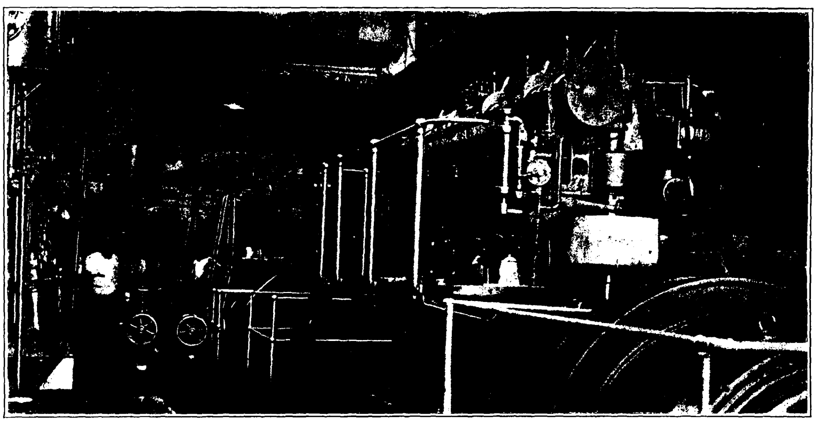

Fig. 2. Diesel engines of Syndicate mill.

Fig. 3. National Coal Company's plant at Butong.

PLATE 3.

Fig. 1. Cupola for iron castings.

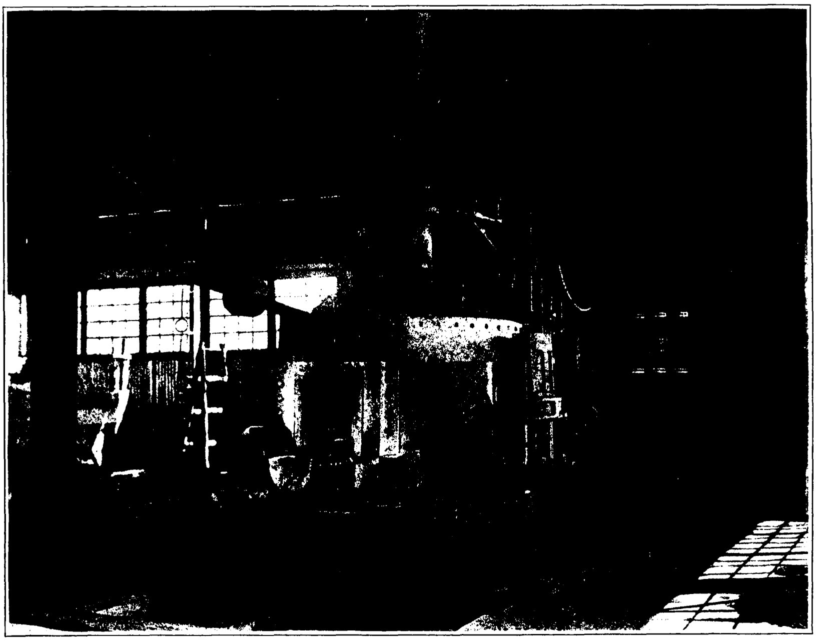

Fig. 2. Heroult electric furnace.

PLATE 4. SHOPS OF ATLANTIC GULF AND PACIFIC CO., MANILA.